Preventive Conservation in Museums

Editor: Chris Caple

Preface

This reader attempts to make some of the key publications of the diverse literature on preventive conservation more readily available. It is an updated version of Simon Knell's Care of Collections published in 1994. This latter book successfully drew together information, largely from the museum literature, on the subject of collections care. Since that date the literature on this subject has grown considerably. A large number of papers are now published by groups of museum scientists in the specialist conservation literature. There are also an increasing number of books on different types of collectable object, from military vehicles to medals, which contain chapters on 'the basic care of …'. The problem with much of the 'care of…' literature is that, although it gives sound advice, it avoids technical terms, symbols and explanations of the chemical basis for the decay or prevention of decay processes. To be able to read and understand this subject at anything beyond the most basic level, these technical terms, the relevant symbols and basic scientific explanations need to be understood. This reader seeks to bridge the gap between the very basic museum 'care of …' literature and the technical and detailed conservation literature.

As this reader aims to provide a picture of our understanding and practices of preventive conservation in the initial decade of the 21st century, the papers are drawn from the last 20 years of research and publishing on the subject. They are a mixture of seminal papers in the subject, such as Michalski (1993) and (Keene 1991), clear introductions to and expositions of the topic, such as Bullock (2006), or case studies which demonstrate current practice, such as Nightingale (2005-6). The observant reader may note that many of the papers are drawn from the mid 1990's. This reflects the influential nature of the research undertaken and publications written in this period. Whilst further research has taken place, leading to more recent detailed appreciation of a number of topics, such as airborne pollutants by Tétreault (2003), in many cases the developments of the mid 1990's are still being implemented in museums. Consequently a significant number of the case studies and summaries from that period remain highly appropriate. One significant change since 1994 is the availability of information on preventive conservation from web sites, such as http://www.collectionslink.org.uk/ via the internet. Many national and international heritage organisations such as the Canadian Conservation Institute (CCI), the Getty Conservation Institute (GCI) and the Collections Trust now make information on preventive conservation freely available via their web sites or through publications. The aim is to raise the standards of care of historic and artistic artefacts throughout the world.

One subject that is crucial to the practice of preventive conservation, which is not covered by this book, is that of materials identification. To apply preventive conservation measures effectively it is important that to know what materials you are dealing with. Is this metal object lead and thus vulnerable to acetic acid vapours or iron and subject to corrosion at high humidity? Is the object plastic and likely to loose plasticiser and devlop a craked and crazed surface or ivory and likely to react poorly to changes in relative humidity? Materials identification is a large subject which is not currently appropriately covered in a succinct published form aimed at museum curators or museum studies students. Though there are a number of basic identification books on individual materials, such 'What Wood is That?' (Edlin 1977), there is nothing comprehensive for the full range of materials in objects collected by museums. It is also arguably not a subject which can be adequately learnt solely from textual sources, you need to handle the actual materials and gain a 'feel' for them if you are to identify them accurately. Unfortunately there is not normally room available in the curricula of most modern museum courses for this type of time consuming 'skilling'. Consequently it is one key aspect of preventive conservation which students must develop themselves.

Finally it will be noted that the title of the book has changed from Care of Collections to Preventive Conservation. This reflects:

- the narrower focus of this reader on the different agents of artefact decay, their monitoring and control
- the existence of many other books which cover subjects such as conservation ethics (Richmond & Bracker 2009) and collections management (Fahy 1995, British Standards Institute 2009) which were included in Knell's original Care of Collections book.
- the widespread adoption of the term preventive conservation since the 1994 IIC Ottawa conference on this subject
- the increased volume of research and the increasingly scientific basis for the work undertaken in this area
- the importance of conveying to both the public and decision makers the high degree of education and training in preventive conservation which museum professionals, whether curators, conservators or collections managers are required to possess in order to practice this subject at a competent level. There is an increasing need to distinguish preventive conservation from the sometimes unspecific activities and attitudes which the term 'care' can evoke.

References

British Standards Institute 2009 *PAS197:2009 Code of Practice for Cultural Collections Management*, London: BSI

Bullock, L. (2006) 'Light as an Agent of Decay', in The National Trust(ed), *Manual of Housekeeping*, London: Butterworth-Heinemann

Fahy, A. (ed.) (1995) Collections Management, Abingdon: Routledge

Keene, S. (1991) 'Audits of care: framework for collections condition survey', in M. Norman and V. Todd 1991 *Storage* (preprints for the UKIC Conference 'Restoration '91'), London: UKIC

Michalski, S. (1993) Relative Humidity: A Discussion of Correct/Incorrect Values. *ICOM-CC 10th Triennial Meeting, Washington, DC, USA.* 624-629

Nightingale, C. (2005/6) 'Designing an Exhibition to Minimise Risks to Costume on Open Display', *The Conservator* 29: 35-50

Richmond, A and Bracker, A. (2009) *Conservation Principles, Dilemmas and Uncomfortable Truths*, London: Butterworth Heinemann.

Tétreault, J. (2003) *Airborne Pollutants in Museums, Galleries and Archives: Risk assessment, Control Strategies and Preservation Management*. Ottawa: CCI

Edlin, H.L. (1977) *What Wood is That?*, London: Stobart & Son Ltd

Readings

Charlie Costain 'Framework for Preservation of Museum Collections', *CCI Newsletter* No. 14, 1-4. & Canadian Conservation Institute, 1994 *Framework for Preservation of Museum Collections* (a poster), Ottawa, CCI

Jonathan Ashley Smith, J. 1997 Risk Analysis, in S. Bradbury (ed.) The Interface Between Science and Conservation, British Museum Occasional Paper No. 116. London: British Museum Press, 123-132

Gwen Miles, G. 1992 Object Handling, in J.M.A. Thompson (ed.) Manual of Curatorship (2nd ed.) 455-458

Paul Marcon, P. Six Steps to Safe Shipment – CCI website www.cci-icc.gc.ca/crc/articles/sixsteps-sixetapes/index-eng.aspx (consulted 13/3/09), 14 pages

Chris Caple, C. 2000 Conservation Skills: Judgement, Method and Decision Making, London: Routledge. (pages 152-4, 156-160)

Jim Tate & Theo Skinner 1992 Storage Systems, in J.M.A. Thompson (ed.) Manual of Curatorship (2nd ed.) 459-467

Peter Winsor 1997 Which Conservation Materials to Use at Home?, in, Museums and Galleries Commission (ed.) Ours for Keeps?, London: MGC (7.07-7.10)

IIC , Before the unthinkable happens again – IIC website http://www.iiconservation.org/docs/IIC_tokyo_transcript.pdf (consulted 20/2/10), 10 pages

Rob Payton 2003 Safety by Numbers, Museum Practice 22, 40-42

Christopher Rowell & Martin Robinson 1996 Uppark Restored. Chapter 1: The Fire and Salvage, London: The National Trust (15-31)

John Martin 2005 Emergency Planning, Museum Practice Spring 2005, 43-59

John Hunter 1994 Museum Disaster Preparedness and Planning, in S. Knell (ed.) Care of Collections, London: Routledge 60-79 (originally in B.G. Jones 1986 Protecting Historic Architecture and Museum Collections from Natural Disasters, Oxford: Butterworth-Heinemann, 211-230)

Dave Pinniger & Pete Winsor 1998 Integrated Pest Management, London: MGC (31 pages)

Linda Hillyer & Valerie Blyth 1992 Carpet Beetle – a pilot study in detection and control, in S. Knell (ed.) Care of Collections, London: Routledge 217-233 (originally in The Conservator 16, 65-77)

Lim Chong Quek, Muhammadin Razak & Mary W. Ballard 1990 Pest Control for Temperate vs. Tropical Museums: North America vs. South East Asia, in, ICOM-CC 9th Triennial Meeting, Dresden, German Democratic Republic 26-31 August 1990, and Los Angeles: ICOM-CC, 817-821

Sarah Stanniforth, Sophie Julien & Linda Bullock 2006 Chemical Agents of Deterioration in, The National Trust, Manual of Housekeeping, London: Butterworth-Heinemann, 69-79

L. Lee & Dave Thickett 1996 Selection of Materials for the Storage of Display of Museum Objects, British Museum Occasional Papers 111 (pages 3-8, 12-17, 37-39)

Sue Bradley & Dave Thickett 1999 The pollution problem in perspective, in Bridgeland, J. (ed.) ICOM-CC 12th Triennial Meeting Lyon 29 August – 3 September 1999, 8-13

Helen Lloyd & Katy Lithgow 2006 Physical Agents of Deterioration in, The National Trust, Manual of Housekeeping, London: Butterworth-Heinemann, 62-67

Helen Lloyd, Katy Lithgow, Peter Brimblecombe, Young Hun Yoon, Kate Frame & Barry Knight 2002 The Effects of Visitor Activity on Dust in Historic Collections, The Conservator 26, 72-84

Cathy Mathias, K. Ramsdale and D. Nixon 2004 Saving Archaeological Iron using the Revolutionary Preservation System, in J. Ashton & D. Hallam (eds.) Metal 04, Canberra: National Museum of Australia, 28-42

Linda Bullock 2006 Light as an Agent of Decay, in, The National Trust, Manual of Housekeeping, London: Butterworth-Heinemann, 92-101

Boris Pretzel 2006 Ephemeral or Permanent: Environmental Decisions for Textiles, in F. Lennard & M. Hayward, Tapestry Conservation, London: Butterworth Heinemannn, 213-218

Dave Erhardt & Marion Mecklenburg 1994 Relative Humidity Re-examined, in A. Roy & P. Smith (eds.) Preventive Conservation: Practice, Theory and Research, IIC Ottawa Congress 12-16 September 1994, Ottawa: IIC, 32-38

Stefan Michalski 1993 Relative Humidity: A Discussion of Correct/Incorrect Values. ICOM-CC 10th Triennial Meeting, Washington, DC, USA. 624-629

Stefan Michalski 1994 Relative Humidity and Temperature Guidelines: What's Happening, CCI Newsletter 14, 6 & Table 1

May Cassar 1995 Environmental Management, Chapters 4, 6 & 7, London, Routledge, 39-41, 77-87, 94-108

Suzanne Keene 1996 Managing Conservation in Museums, Chapter 9, London: Butterworth-Heinemann, 136-158

Helen Kingsley & Rob Payton 1994 Condition Surveying of Large Varied Stored Collections. Conservation News 54, 8-10

Diane Dollery 1994 A Methodology of Preventive Conservation for a Large Expanding and Mixed Archaeological Collection, in A. Roy & P. Smith (eds.) Preventive Conservation: Practice, Theory and Research, IIC Ottawa Congress 12-16 September 1994, Ottawa: IIC, 69-72

Miriam Clavir 1994 Preserving Conceptual Integrity: Ethics and Theory in Preventive Conservation, in A. Roy & P. Smith (eds.) Preventive Conservation: Practice, Theory and Research, IIC Ottawa Congress 12-16 September 1994, Ottawa: IIC, 53-57

Ann Drumheller & Marian Kaminitz 1994 Traditional Care and Conservation, the merging of two disciplines at the National Museum on the American Indian, in A. Roy & P. Smith (eds.) Preventive Conservation: Practice, Theory and Research, IIC Ottawa Congress 12-16 September 1994, Ottawa: IIC, 58-60

Bob Child 2006 Conserving a Coal Mine: Keeping our Industrial Heritage Working, in, C. Buttler & M. Davis (eds.) Things Fall Apart …, Cardiff: National Museum of Wales, 24-31

Glenn Wharton, Sharon Blank & Claire Dean 1995 Sweetness and Blight: Conservation of Chocolate Works of Art, in J. Heuman (ed.) From Marble to Chocolate: The Conservation of Modern Sculpture, London: Archetype, 162-170

Museums & Galleries Commission 1998 Levels of Collections Care: A Self-Assessment Checklist for UK Museums, London: MGC

Suzanne Keene 1996 Information for Preservation, Managing Conservation in Museums, Chapter 8, 112-135

Catherine Nightingale 2005/6 Designing an Exhibition to Minimise Risks to Costume on Open Display, The Conservator 29, 35-50

Siobhan Watts, Janet Berry, Amy de Joia, Fiona Philpott 2002 In Control or Simply Monitoring? The Protection of Museum Collections from Dust and Vibration During Building Works, in R. Vontobel (ed.) ICOM-CC 13th Triennial Meeting Rio de Janeiro 22-27 September 2002, 108-115

Sue Renault 2006 Make Yourself at Home: Looking After an Open-Air Museum, in, C. Buttler & M. Davis (eds.) Things Fall Apart …, Cardiff: National Museum of Wales, 6-14

Julian Bickersteth, Sarah Clayton & Fiona Tennant 2008 C Conserving and Interpreting the Historic Huts of Antarctica, in, D. Saunders, J.H. Townsend & S. Woodcock (eds.0

Conservation and Access, Contributions to the London Congress 15-19 September 2008, London: IIC, 218-220

Julian Carter 2006 Breaking the Code: Conserving DNA – New Demands on Natural Science Collections, in, C. Buttler & M. Davis (eds.) Things Fall Apart …, Cardiff: National Museum of Wales, 16-22

May Cassar & Robyn Pender 2005 The Impact of Climate Change on Cultural Heritage: Evidence and Response, in Paterakis, A. et al (ed.) ICOM-CC 14th Triennial Meeting The Hague 12-16 September 2005, 610-616

The History of, and an Introduction to, Preventive Conservation

Chris Caple

What is preventive conservation?

Artefacts[1], whether tools for cutting or pictures for viewing, are functional objects (Caple 2006, 8-13). They are maintained during their working lives by their owners to ensure they remain functional and effective. Thus, the good carpenter ensures that his tools are cleaned, sharpened and, if stored, have a light coat of oil to prevent corrosion. This ensures that they can continue to function effectively in this initial 'use' phase of their life. When the carpenter's tools enter a museum collection, they cease to fulfil their original function and become part of collections which are to be preserved in perpetuity. Their new role (function) is to preserve and display evidence of the past. This is invariably the final or curation phase of the object's life (Caple 2006, figure 1.3). If any object is to function effectively as part of a museum collection then it must be prevented from corroding or decaying; preserved in its present state since loss or deterioration would reduce or eliminate its ability to perform its museum functions of being a research subject or display item. It is the efforts to preserve, balanced with the needs to reveal and investigate the object and its values which can be understood as conservation (Caple 2000, 33-35). Activities, particularly those associated with preserving the object, that occur without physical interaction with the object can be regarded as preventive conservation. Preventive conservation can be defined as any measure that reduces the potential for, or prevents, damage. It focuses on collections rather than individual objects, non-treatment rather than treatment. In practical terms handling, storage and management of collections (including emergency planning) are critical elements in a preventive conservation methodology (Getty Conservation Institute 1992)

Preventive conservation absorbs products and ideas from the world of modern industry and commerce and applies them, where appropriate, to museum objects. Ideas such as oxygen free storage come from the food preservation industry, products like bubble wrap from the packaging industry, disaster planning from the fire prevention industry, air conditioning from the building industry. All these products and ideas have to be assessed for application to precious artistic and historic works. Whilst they must be effective, crucially there is an ethical requirement that no element or valued aspect of the original artefact should be altered or lost in the preserving process. In practical terms they also need to be cost effective as the museum and heritage industry invariably has limited resources.

Preventive conservation has also looked back to 'traditional' practices, in a range of cultures. Traditional methods often have the benefit of being low energy solutions, using natural materials and sympathetic to other aspects of human existence. Whether closing a country house over the winter, using blinds or curtains, keeping objects in boxes or chests, such practices are often highly effective in minimising decay rates. The evidence of surviving objects which have been the recipients of such practices, demonstrate the effectiveness of such strategies over the long term.

Regardless of whether new or traditional methods and materials are used, only if artefacts are valued, are resources made available to preserve them. So the first requirement for preventive conservation is to ensure that society values the object.

History: Preventive conservation - prehistory to the mid nineteenth century

The idea that ancient artefacts have always been valued by humankind appears well attested by archaeologists who have found significant numbers of ancient objects in more recent contexts, such as Roman jewellery in Saxon graves (White 1988, 1990). Some of the earliest surviving structures of human settlement in Europe, megalithic tombs on the western seaboard of Spain, France and Britain appear to be made deliberately using stones which have been decorated by earlier peoples (Bradley, R. 2002). Some artefacts preserve evidence which goes beyond being valued and thus collected, they display evidence of veneration (retained, cleaned, repaired and restored). The Coppergate Anglian helmet was retained and used for well over 100 years after its manufacture and shows clear evidence of continued and extensive cleaning through the nature of its worn decoration (Tweddle 1992, 980-2) whilst the Saxon brooch from Harford Farm, Caistor St Edmund, Norfolk, shows evidence of careful repair by a Saxon metalsmith called Luda (Tudda?) (Hinton 2005, 79). It could be suggested that the cleaning and repair of even 'older' objects could be interpreted as maintaining their initial (original) function. However, some older artefacts, such as the examples of shattered Roman Samian pottery vessels which have been held together with lead strips and rivets (Marsh 1981, Ward 1993) or broken 17th century wine glasses held together with wire (Willmott 2001), demonstrate a desire to maintain an object as an heirloom, since in its repaired form it no longer has the strength or integrity to fulfil its initial function. Its age and original appearance (shape) have now become its key values; it functions as an heirloom, acting as a mnemonic to draw viewers into remembrance (Jones 2007, Haug 2001, 112).

From the point that we ceased to be hunter gatherers and became settled agricultural communities living in permanent dwellings we have retained objects that have become symbols of personal and cultural identity (Rowlands 1993). Artefacts have become powerful totems, endowed with social, religious or personal significance, from the crown jewels to parts of the 'true cross', possessing them gives the holder power. Steps have invariably taken to safeguard and to care for these artefacts; it appears that we always look after the things we love (value). By the time of the Greek and Roman civilisations, artefacts such as the prized possessions of conquered peoples, were routinely held in the temple treasuries of victorious Greek and Roman cities as 'physical proof' of the power of their gods . In Rome these collections were cared for by senate appointed officers. In the Roman Republican period these officials were known as *censors* and *aediles;* the *censors* primarily catalogued and distributed the objects, the *aediles* were responsible for the maintenance and security of the buildings and their contents. From the Augustan period onwards both functions were performed by the imperially appointed *curators* (Strong 1973). Written sources from this period indicate that the Romans had both knowledge and appreciation of art and a good understanding of the processes of decay.

- Seneca reminds his readers that a bad light can ruin pictures (Strong 1973, 258)
- Vitruvius recommends north light for pictures since it is steady and does not alter through the day (Strong 1973, 258)
- Pausanias records that the ivory parts of the statue of Zeus were treated with oil to prevent damp, whilst the ivory of the Athena Parthenos was deliberately kept damp (to avoid drying out and presumably cracking) (Strong 1973, 261)
- Pausanius also mentions treating bronze shields in the Stoa Poekile with pitch presumably to preserve them against water and prevent them corroding (Strong 1973, 261).
- Pliny the Elder remarks that in the third century BC the Greek artist Apelles of Cos applied a thin black varnish to his paintings since it 'enhanced the brilliance of the colours and protected from dust and dirt' (Abey-Koch 2006, 32)

- Pliny describes four types of wood boring insect and suggested making objects out of cypress, as the bitterness of this wood deterred wood boring insects, or hardwoods such as boxwood as they prevented the birth of these insects (Abey-Koch 2006, 28). He also suggests treating papyrus with citrus oil to deter insect pests (Pye 2001, 40)
- Pliny wrote of the corrosive effects of timber on lead (Rackham 1968, 253)
- The problem of loss and damage of collections from fire was evident to many ancient writers. Fire destroying the Forum Pacis and its ancient statues in AD 191, it also badly damaged the Forum Caesar and the Theatre of Pompey and their associated works of ancient art in the 3rd century AD (Strong 1973, 26). In AD 483 an inscription records the restoration of a statue of Minerva, the goddess protector against fire, which had, ironically, been badly damaged by fire (Strong 1973, 263).

Educated ancient Romans were thus well aware of the processes of decay and the potential loss of artefacts from disasters such as fire. The active roles of cleaning, coating and restoration have subsequently developed into the processes of interventive or remedial conservation. Those of shielding objects from light, insects, damp, fires and theft have evolved into preventive conservation. The names of a number of the *censors*, *aediles* and *curators* have come down to us. Thus, a *curule aedile;* T. Septimus Sabinus, who is referred to by Pliny, as returning a statue of Hercules to public view (Strong 1973, 252) and is one of the earliest named individuals we can identify as practising preventive conservation.

The concept of preserving valued artefacts from the ravages of the natural world continued in the medieval period: paintings of the late medieval period often had shutters or curtains in front of them to protect from the effects of light (Campbell 1998, 17). There was also recognition of the risks involved in moving objects. In 1454 the artist Neri sold a panel painting to Antonio dalla Lastra who took it away packed in a pair of large baskets, but on the journey home he collided with a mule who kicked the baskets and broke the panel painting into 12 fragments, which the artist then had to piece back together for his client (Thomas 1998, 5). This, and no doubt many other incidents, caused some to take great care when transporting works of art. In 1399 the artist Brederlam, when dispatching the newly painted wing panels of a triptych to his client, packed them in a crate made of elm wood, lined with leather and stuffed with cotton. The crate was also wrapped in 22 ells of waxed cloth (presumably to make it waterproof) (Campbell 1998, 18). By the Renaissance the creation of purpose built containers to protect (and display) art had developed to the point that the earliest galleries and museums were being constructed, such as the upper floor of the Uffizi constructed by Francesco I (1541-1587) and the art gallery (1563-7) and museum (1569-73) built by Albrecht V, Duke of Bavaria.

The role of the closable container, such as the box, has long been appreciated as one of the most effective forms of preventive conservation. A box excludes light, is a barrier against pests, provides insulation against temperature and relative humidity (RH) change and it crucially provides physical security and some measure of protection against disasters such as fire and flood. Boxes of strong smelling woods such as cedar, or containing herbs such as lavender have a long tradition of repelling insects such as moths and were thus used for storing clothing in the late and post medieval period. Containers such as portfolio made of pasteboard or thin wood are identified as early as 1439 for protecting prints and drawings (Hicks 1988, 7), other forms of physical protection such as the use of mounts, frames with and without glazing, are utilised from the 17th century and become widespread by the 18th (Hicks 1988, 8). Weapons such as swords were kept in fleece lined scabbards, giving the iron blade a coating of water repellent lanolin (the natural grease of wool) every time it was drawn or inserted, so keeping the blade from corroding (Nissan 1999, 111).

Though emperors, kings, lords and princes took great pride and interest in their treasured processions and lavished resources on them, the basic tasks of care and cleaning were often done by household servants, indeed some of the early *censors* and *aediles* were public slaves. In the absence of courses and books, from the Roman period to the 18th / 19th century, it was through practice and oral tradition, that the skills of cleaning, storing, de-infestation and repair were routinely passed on from one generation of household servants / slaves to the next. The late medieval period, like the late Roman Republic period was a time when displays of wealth through possessions such as books and clothing were important to the aristocracy and by the 16th century this information began to be written down e.g. *The Jewel House of Art and Nature* by Sir Hugh Platt (1594). Books on caring for household possessions become more common in the 18th and 19th centuries, such as *The Housekeeping Book of Joanna Whatman 1776-1800* and Mrs Beeton's *Housewife's Treasury of Domestic Information*, published in 1865 (Abey-Koch 2006). These publications fixed and made available knowledge based on empirical observation and provided a wealth of practical 'how to do' information. They demonstrate that environmental phenomenon and their effects such as damp and moulds, light and fading were well understood on a cause and effect basis.

In summary, from prehistory to the mid nineteenth century artefacts were collected and preserved principally by private individuals. Only a small number of powerful organisations acquired objects; The Roman state, religious organisations such as the Catholic Church, late medieval towns such as Basel (who acquired Amerbach's collection in 1661), and from the late 18th century the emergent European nation states who started to found national museums. In most cases the objects are either; curiosities, related to family ancestry, or are evidence for religious belief or secular power. As materials were scarce and valuable, efforts were generally made to preserve all types of artefact, weapons, tools, even clothing. The same techniques and ideas were used to protect and maintain ancient artefacts as to preserve and maintain functional tools and weapons. Preservative measures were invariably applied by servants or craftsmen to the artefacts of their masters or clients. Such measures were applied to valued artefacts in order to maintain the artefact's visual appearance and involved active cleaning and mending as well as protection from agents of decay. Natural agents of decay were clearly understood and, although literature on this subject was limited, understanding may have been widespread. Whilst the origins of preventive conservation lie in this period, it is not yet clearly distinguishable as preventive conservation, since the objects are often not distinguished from any other functional objects and there is no differentiation between interventive and preventive measures.

Preventive conservation in britain - the mid nineteenth century to the 1990's

The development of rational thought, observation of the natural world and experimentation from the 17th century onwards had, amongst other things, led to the foundation of scientific principles and the establishment of museums by the 19th century. Collection and classification, initially applied to the natural world, had also been utilised in the study of artefacts of the ancient past, leading to an understanding of human development and the creation of a material and culture classification sequence of the past exemplified by C. J. Thomson's 'Three Age System' (Stone, Bronze and Iron Ages). By the mid 19th century science was being applied to provide a chemical, physical or biological explanation for the numerous phenomena of the natural world, including the mechanisms of decay. By 1843 Michael Faraday was publishing research into the decay of the leather book bindings in the vicinity of gas lamp burners (Caldararo 1987) whilst in 1861 Brewster and in 1880 Fowler had published papers on glass decay. In 1888 Russell and Abney studied the effect of light on watercolours and by 1921 Alexander Scott had identified acetic acid as the cause of active corrosion of lead (Bradley S.

2002, 3) and was aware that lead white was blackened by the presence of sulphurous gases (Lee & Thickett 1996, 3). These observations emphasised how damaging the gaseous environment could be to works of art, a topic which was also highlighted in the parliamentary enquiry of 1853 into the cleaning of pictures in the National Gallery. An awareness of the damaging effect of the atmosphere was not new. Brimblecombe has shown (1977, 1978) that as early as the 13th century people were aware of the damaging effect of coal burning. In 1661 Evelyn in his book *Fumifugium* could write:

> 'the weary traveller, at many Miles distance, sooner smells than sees the City to which he repairs. This is that perniscious Smoake which sullyes all her Glory, superinducing a sooty Crust or Furr upon all its lights, spoyling the movables, tarnishing the Plate, Gildings and Furniture , and corroding the very Iron-bars and hardest Stones; and executing more in one year, than exposed to the Aer of her country it could effect in some hundreds…Finally it spreads yellowness upon our choicest Pictures and Hangings…' (Brimblecombe 1978)

It was, however, the science of the 19th and 20th century which provided explanations of how and why gases could damage artefacts. By the late 19th century, the deleterious effects of the environment were well understood with the need to protect artefacts from light, damp and polluting gases were being discussed in scientific journals and by the early 20th century the first books on conserving ancient artefacts, such as Friedrich Rathgen's '*The Preservation of Antiquities*' published in 1905, (Gilberg 1987), were starting to appear.

In the mid 19th century the number of museums in Britain had started to increase due to an increasing belief in the benefits of education and self improvement, and the passing of the Museums Act of 1845 which permitted local authorities to set up museums using the local rates. Though this led to the collection and protection of many artefacts preventive conservation practices were not yet widespread because:

- there was a lack of trained personal; there were no conservators or museum scientists and curators, who rarely had a background in science, were not trained in artefact care
- a lack of resources
- it was not considered a high priority for the limited resources available.

Events in the First World War led to a perception that there could be significant damage to national museum collections from aerial bombardment . Both the British Museum and National Gallery moved significant items of their collections into the museum / gallery basements. By 1917 the threat from high flying Zeppelins and more powerful bombs was growing, so the National Gallery moved part of its collection to the new underground railway station at Aldwych, which was converted through adding heating and ventilation to reduce the damp, to a store for small and medium sized paintings (Saunders 1992). Early in 1918 part of the British Museum's collection was moved into the Holborn Post Office Tunnels, again, aware of the risk of damp, electric radiators and ventilation were installed and temperature and relative humidity levels monitored (Caygill 1992). Harold Plenderleith has suggested that, despite these precautions, after the war the discovery of mould, corrosion and soluble salts damaging the collections of the British Museum resulted in Dr Alexander Scott of the British Government's Dept. of Science and Industrial Research being seconded to the British Museum during the 1920's to provide greater scientific input to the preservation of the collections (Plenderleith 1998) and ultimately to the establishment of the British Museum Research Laboratory in 1931.

From the 1930’s onwards, as a result of World War 1 and the Depression, the role of governments and the regulation of populations increased. This led to increasing ownership of collections by the state and these encouraged the development of defined standards of care for this public property. Thus the period divides into two, the period before the 1930’s and the period after the 1930’s.

By the late 1930’s, well before the outbreak of the Second World War, institutions such as the British Museum and the National Gallery were concerned about the risk of bombing, and made preparations. Consequently, on August 24th 1939, before war was declared on September 3rd, the British Museum started packing up its collections and moving them out to country houses such as Broughton and Drayton. Library materials went to the National Library of Wales at Aberystwyth, where a tunnel store in the hillside was just becoming available, and the ‘imperishable’ antiques went into Underground railway line tunnel at Aldwych. Careful assessment of the conditions and risks at each venue had led to selection of the most appropriate objects being moved to the most appropriate locations. At the same time, The National Gallery collection was evacuated to Bangor University and Penrhyn Castle in North Wales, as well as the National Library of Wales at Aberystwyth. In 1940 the collections were further dispersed to Caernarvon Castle and a county house ‘Plas-yr-Bryn’. Following the intensive bombing of the Blitz, concerns were raised over the safety of all museum and gallery collections stored above ground. For the British Museum, caverns, in the Bath stone quarry at Westwood near Corsham, were prepared. Influenced by the problems experienced in the First World War, a stable mid range RH environment was created by sealing the stone walls and installing air conditioning equipment, as well a backup system. In late 1941 the British Museum collections were moved from their various locations to this underground store, where they stayed in stable conditions (65-75°F, 60-65% RH) until the end of the war (Caygill 1992). For the National Gallery the slate caverns at Manod near Ffestiniog were prepared. A larger entrance was created and brick buildings constructed within the giant caverns, where the air (a constant 8°C) could be heated to provide constant conditions of 58% RH and 17°C inside the brick buildings. The paintings stayed in this ultra stable environment until they were returned to London at the end of the war. Impressed with this facility, the National Gallery retained the Manod site though out the Cold War until the early 1980’s, ready to evacuate the collection to the safety of North Wales if required (Saunders 1992). At both Westwood and Manod excellent storage conditions had been created and the ability to create ‘ideal’ storage conditions shown to be achievable. Having fought for such conditions, the directors of the British Museum and National Gallery had effectively defined the ‘appropriate’ standards for the storage of their collections, not a position from which they could easily retreat. Subsequent years were spent trying to bring their own institutions up to those wartime standards.

After the Second World War independence was sought by many former colonies of European countries and many of the emergent countries in North Africa, South America and Asia started to develop national museums. These continued the trend in the internationalisation of museums which had started in the 1930’s. This emergent international museum community had begun to publish articles on aspects of care and conservation of museum artefacts in the new museum journals such as The Museums Journal (UK) (est. 1901), Museumhinde (Ger.) (est. 1905), Museum News (US) (est.1924) and Museion (Ger.) (1927-1947) later Museum (UNESCO) (1948-). By the 1950’s the colonial practices of removing objects from all corners of the world to the great European treasure house museums ceased and museum staff increasingly found ‘recognition’ through exhibitions, publications, research and scholarship. Some of these publications related to developments in care of museum artefacts.

In Britain the development of the Welfare State saw a wide range of services and industries brought under state control. These developments were part of a conscious attempt to improve the quality of life for the public as a whole. Legislation such as the Clean Air Act, which prohibited burning coal in densely populated urban areas was adopted in the UK from 1956 as part of a series of measures to improve public health. Whilst this had the fortuitous effect of improving the environment surrounding works of art in British cities, other developments from this period, such as modern architecture that utilised large areas of glass, had a detrimental effects on museum artefacts; increasing light levels, RH and temperature fluctuations. Increases in leisure time and education in the 1950's and 1960's brought many people to view museums and historic houses. This resulted in many historic artefacts and artworks being brought into the limelight of display. The polymers which had began to be used in the early 20th century as adhesives consolidants and storage materials for ancient artefacts and which increased in number and availability after the Second World War began to seen as not always beneficial, some began to break down altering the appearance of artefacts. Continued progress in science and technology and the experiences of environmental control at the British Museum and National Gallery in the Second World War led Sue Bradley, writing in 2002 to state 'most of the problems of collection care were elucidated by the 1950's (Bradley S. 2002, 3). Whilst the principles may have been elucidated, there continued to be a lack of knowledgeable staff and a shortage of resources which ensured that object care remained a low priority. Consequently implementation of preventive conservation measures remained limited. Only in 1967 did the IIC (the International Institute of Conservation for Historic and Artistic Works, founded in 1950 an international organisation for museum conservators) dedicate a whole conference to *Museum Climatology* (Thomson 1968). Knowledge in this sector was consolidated and brought to the attention of the wider museum and conservation world through the publication of Gary Thomsen's book *The Museum Environment*, in 1978. The establishment of Area Museum Services in the UK from 1963 ensured that advice and monitoring equipment to implement preventive conservation was available to all smaller and regional museums. The establishment of conservation courses in universities such as Cardiff and Durham in the mid 1970's increased the flow of qualified conservators. But it is Thomsen's book, more than any other single measure, which has made a wider museum world aware of what needed to be done to safeguard museum collections. One of the discernible benefits of the books, qualified staff was the increasing adoption of a series of standards for light and humidity which emerged from the experiences of British, European and North American Museums in the years after the Second World War.

In summary, in the emergent international museum culture of the 20th century, preventive conservation was a minor topic until the World Wars forced European museums to think seriously about continued preservation of their collections. Developing from the scientific progress of the 19th century, awareness of the chemical, physical and biological basis for decay had advanced significantly. The concepts of conservation and preventive conservation had emerged, with recognition of the value of the historic information present within artefacts and an awareness of the need for an ethical approach to their conservation (Caple 2000, 55; Pye 2001, 52). New techniques for measuring pollutants (gases, RH) and new materials opened up the possibility of scientifically improving conditions for artefacts. In Britain, it was arguably the increase in public ownership of works of art in the 19th and 20th century and the social changes engendered by the World Wars which created both the ability and the will to ensure that standards in the preservation of museum collections were developed and implemented. However, at the same time, the vast expansion of the collections and the increased expectation of seeing artefacts on display, created further challenges to the implementation of such standards.

Preventive conservation - 1990's to the present

By the 1980's knowledge of collections care was becoming well established throughout the museum world. A series of appropriate environmental (minima and maxima) levels for humidity and the lighting of different types of museum artefact, had been established. This information was being disseminated through Thomson's book and an increasing number of conservators and curators well versed in the literature about preventive conservation were emerging from university. Insect problems were receding after several decades of using insecticides, the use of 'archival' materials was increasing and museums invariably had access to light and relative humidity monitoring equipment.

Continued developments in science and technology were, however, leading to an increasing number of new materials and devices. In particular there were considerable developments in the sensitivity and availability of devices for monitoring gases, humidity, light etc. This increasingly ability to monitor a wide range of gases at lower and lower levels inevitably led to suggestions that museums and archives should have clear air environments with very low levels of pollutant gases tolerated (Hatchfield 2002, 22 - 23). Examples include the National Air Filtration Association who proposed limits for archives of 1ppb (parts per billion) for SO_2, 2.6 ppb for NOX, 2 ppb for O_3 and the Canadian Conservation Institute proposed upper limits for general museum collections of 10ppb for NOX, 5ppb for O_3 and 15ppb for SO_2 (Grzywacz 2006, 109). The most significant technical development which changed the nature of the subject was computers. Initially large and expensive they failed to have any significant role in museums in the decades after the Second World War. However, by the 1990's computers were sufficiently small and powerful to be present in every museum. Their ability to store and manipulate vast amounts of data meant that it was possible to continuously monitor and acquire data about the museum environment in many locations. Museums went from a situation in the 1950s of often having little or no data on a museum's environment to having too much data by the 1990's. The computer was, however, also the tool which would enable the museum to manage its collections and environment. The large volume of RH and temperature data was not, however, the only problem. The widespread availability of RH levels and the constant use of such numbers encouraged those lending objects to request increasingly stringent RH levels. Such stringency articulated the 'value' of their objects, through such requests frequently failed to understand the inherent limitations in measuring and maintaining RH levels (Ashley Smith et. al. 1994). These stringent loan levels were often not realistic and could not be achieved in the objects 'home' institution, let alone the loaning institution. Some of the specified light levels were also often so low that visitors with less than perfect eyesight could not distinguish the colour or detail in artefacts such as prints, drawings, textiles and manuscripts.

For many museums and heritage organisations the suggested air quality and RH levels were unrealistic given the costs of the air purification /air handling plant required to achieve them, and the staff to monitor and maintain such environment levels. Also, given the nature of the collections, the nature of the existing historic museum buildings and their internal fixtures and fittings, and the continued requirements for visitor access, many of the polluting gases and RH levels were simply unachievable in practice. An increasing separation of what was technically achievable and what it was realistic and affordable was emerging and this prompted renewed research into what was really necessary. The question was increasingly, why there was so much emphasis placed on measuring and controlling light and RH in very tight terms, when there were many other threats, from disasters such as fires, artefacts being stolen or damaged from handling and moving objects between exhibitions? A museum trying to achieve tight RH control when it lacked a smoke detector was clearly an absurdity. All of this meant a move to an increasingly holistic approach to the subject of preventive conservation.

These and other concerns combined to lead to a major change in emphasis in preventive conservation around the mid 1990's. In 1992 the IIC held their biennial conference in Ottawa; *Preventive Conservation: Practice Theory and Research* (Roy & Smith 1994), several of the papers at that conference reflected recent developments in the approach to preventive conservation. Key concerns which have shaped research and practice in preventive conservation from the 1990's onwards have included:

- The need for the many threats to objects needed to be objectively appraised. This resulted in the quantification of risk and the application of risk analysis methodology to museum objects (Ashley Smith 1999, Waller 2003). The concept of object 'loss per annum' (Chapter 2), enabled researchers to compare the threat of damage to objects from a wide variety of sources from light to earthquakes.
- Utilising risk analysis as well resource information for the full range of threats to artefacts led to a far more holistic and realistic approach to the subject of preventive conservation. This is exemplified by CCI's *Framework for the Preservation of Museum Collections* (Chapter 1) and the MGC's *Levels of Collections Care* (Chapter 35). Most usefully expressed in table form this enabled resources to be prioritised to mitigate the greatest threats.
- A recognition that we were not measuring object damage but the more easily measured quantity of deterioration agent (light level and wavelength, gas concentration, temperature and relative humidity). It was also appreciated that deterioration was a very complex phenomena which depended on many variables which often acted synergistically together. Thus the damage to an artefact from light depends not only on the wavelength and intensity of the light but also on the levels of oxygen present as well as the nature of the recipient material (Chapter 23). Similarly the damaging effects of polluting gases are often determined by the level of relative humidity (Chapter 18). Thus, measuring one chemical agent to a high level of accuracy is often not the most effective way of assessing the risk of damage to an object.
- Social concerns about the hazards to human health from chemicals were increasing. Governments in Europe, North America and elsewhere in the world started to pass legislation banning certain chemicals, reducing exposure to others and above all raising awareness about assessing the risk from using chemicals. In the UK this was seen in the issuing of the 1986 Control of Pesticide Regulations and the 1994 Control of Substances Hazardous to Health Regulations. These led to significant re-appraisal of the risks to the staff and museum collections especially from fumigation for insect eradication (Chapter 13).
- An increase in the role of managements, in particular the development of collections management. This led to the adoption of management and information systems, data analysis and use of project management skills to manage museum activities and seek to exploit collections as a resource. From condition surveys to zonation these techniques were developed to make best use of the museum's resources (heat, light, expertise) as well as to improve the care of the collection.
- There was increased concern over the rights of indigenous peoples and their material culture. This was signalled through the passing of legislation such as the Native Graves Protection and Repatriation Act in 1994 in the USA, the frequently revised Burra

> Charter (1979-1999) in Australia and the Nara Conference on authenticity in 1994. This signified an increasing awareness of other cultures and that other 'non traditional' ways of looking at artefacts had validity (Chapters 31 & 32). This was also expressed in an increased appreciation of the importance of context in understanding artefacts. Consequently we have seen far greater efforts being made to preserve archaeological and historic sites 'in situ' in recent years (Chapters 33, 39, 40).

Subsequent work in preventive conservation has embraced these ideas with many museum scientists, conservators and curators moving from describing preventive conservation through a series of simple maxima limits for relative humidity, light and polluting gases to talking about increasing or reducing risk, using annual exposure limits (an idea from health and safety literature) and the problems of synergistic effects (as one decay agent influences another). This change has been portrayed by Waller and Michalski as a paradigm shift (Waller & Michalski 2004). Preventive conservation in the 19th to 21st century can thus potentially be divided into three eras, 19th century to the 1930's, 1930's to 1990's, the 1990's to the present, see Table 0.1. The chapters in this reader are either key papers in this paradigm shift or they explore current practice in preventive conservation following the changes of the 1990's.

In summary, since the mid 1990's the subject of preventive conservation has started to evolve from simple dos and don'ts into a subject requiring considerable professional judgement where trade offs and balances are exercised. Annual exposure limits for light are increasingly practised rather than simple maximum levels. More realistic appraisal of relative humidity levels requires more detailed appraisal of each object and selection of some objects for loans and not others. The simple minima and maxima limits have not been abandoned but they are capable of being traded in for more refined concepts such as 'increasing risk of damage as we approach extreme high or low RH'. Museums are increasingly relying on management systems, processes or procedures to ensure that risks are assessed and minimised. Integrated pest management relies on regular trap collection and replacement, RH, temperature, particulate and gaseous pollutants levels need not only to be monitored but the data analysed and problems noted and systems amended. Oddy tests need to be performed, quarantine procedures observed. Increasingly this is a managed system, but all organisations change and systems fail. As this introduction has already shown, Roman *curators* knew many of the basics of preventive conservation over 2000 years ago. Given high levels of staff turnover, variable skills, limited funding, short term project funding, changing priorities and an increasing expectation over the quality and duration of exhibitions how good is our ability to manage in the long term? Few management systems last a decade, few organisations last a century but many of our objects have been in our care for thousands of years. Empires collapse but artefacts endure.

Preventive conservation in the future

From this brief history it is clear that the deleterious effect of pollution, the effects of light or damp on our treasured processions is not a modern subject which has emerged in the late 20th century but has ancient origins. This book has a long line of precedents which stretch back to the Roman republic. However, the advent of scientific explanation in the 19th century moved the subject from one of empirical observation of cause and effect to a science in which the exact chemical mechanisms of decay were identified. Since the 1990's preventive conservation has started to focus on a holistic approach, identifying the greatest threat and seeking to reduce it. Considered optimistically museums may be slowly coming to grips with the preventive conservation problems presented by their present collections. Some of the next generation of ideas that will affect preventive conservation practice are already starting to emerge. These include:

- Predictive Modelling of systems such as building environments (air movements and thermal masses) and their fluctuation over time. This is increasingly being done for historic building such as the Sistine Chapel or the Chiericati Palace (Bernardi & Camuffo 1995) in an effort to explore in what ways it is possible to minimise harmful effects such as condensation on windows, or high relative humidity and mould growth behind pictures, furniture or panelling. This detailed modelling relies in gathering large volumes of data from known conditions to construct a mathematical model which mimics the reactions of a building and its contents. Then the reactions to a series of proposed conditions are generated. Predictive modelling has already been used to explore likely changes in the planet's climate and postulate what effects these climate changes will have on the heritage (Chapter 42). This should enable mitigation measures to be planned well in advance, but raises problematic ethical and resource issues. Predictive modelling can also be adapted to consider risk and explore the levels of risk associated with small changes within the museum, even an individual object being moved from one wall of a gallery to another (Waller & Michalski 2004).

- The preservation of chemical, microscopic physical and biological evidence, such as DNA (Chapter 41), which is not visually obvious but which contains crucial information about the past is a new challenge for preventive conservation. Strategies will need to be found for identifying artefacts rich in the microscopic and molecular information and effective conservation strategies developed for preserving it. This could require visually intrusive methodologies such as freezing which are not compatible with display. There is potentially a widening gulf in the requirements for preservation and display, especially display in more extreme 'in context' or 'in situ' locations. This problem already exists for many 'working' objects and open air museums, such as Beamish. Working objects, such as Stephenson's 'Rocket' have been incorporated into several restorations, and the point has now been reached where the original material is no longer discernible. This loss of such valuable research material is of great concern (Mann 1994) as one aim of heritage (display/education) has obscured the other (research). Although we have many working examples of aircraft, such as the Spitfire, from World War II, we increasingly lack any untouched examples, so how will we answer research questions about the materials and technology of the Second World War in the future? The solution requires that two objects are saved, one preserved as historic record, stored for future investigation and research purposes, the second used for active display and capable of being restored.

Each generation values its museum collections in slightly different ways. The symbols of conquered society, the aesthetic values of classical civilisations, the evidence of human development revealed through the increasing sophistication of artefacts and now microscopic traces of use and the intangible beliefs and meanings associated with artefacts. Preventive conservation adapts to care for museum collections to ensure all aspects of the artefacts which society values are preserved and visible. It also responds to wider social changes, improvements in technology, social organisation and adaptions to available resources and prevailing environmental conditions. As these change so does preventive conservation.

Notes

1 In this introduction I focus on archaeological and historic artefacts. Similar arguments can be advanced for the application of preventive conservation to all types of collected material; natural history specimens, works of art, devices or specimen illustrating scientific principals or natural phenomena. In fact anything that has an attribute which

a society or an individual considers worthy of collection and curation regardless of whether in a museum, mansion, house, hut or home.

I also focus on the development of preventive conservation in the UK within an international context. Though many aspects of this history will be similar for other countries, the social, political and economic realities of each country will have determined the extent to which preventive conservation is practised within that country.

The terms artefact (any thing made by human artifice from a building to scratches made on a piece of bone) and object (a physical entity, normally one capable of presentation e.g. in a museum) are used interchangeably. It depends on the culture from which you come or the academic tradition in which you have studied, which is the most familiar.

References

Abey-Kock, M. (1996) ‘History of Housekeeping’, in The National Trust *Manual of Housekeeping*, London: Butterworth-Heinemann.

Ashley-Smith, L. Umney, N. and Ford, D. (1994) ‘Let’s be Honest – Realistic Environmental Parameters for Loaned Objects’, in A. Roy and P. Smith (eds.) *Preventive Conservation: Practice, Theory and Research*, IIC Ottawa Congress 12-16 September 1994, Ottawa: IIC.

Ashley-Smith, J. (1999) *Risk Assessment for Object Conservation*, Oxford: Butterworth Heinemann.

Bernardi, A. and Camuffo, D. (1995) ‘Microclimate in the Chiericati Palace Municipal Museum, Vicenza’, *Museum Management and Curatorship* 14: 1, 5-18.

Bradley, R. (2002) *The Past in Prehistoric Societies*, London: Routledge.

Bradley, S. (2002) ‘Preventive conservation: the research legacy’, in J. Townsend, K. Eremin and A. Adriaens (eds) *Conservation Science 2002*, London: Archetype Publications.

Brimblecombe, P. (1977) ‘London air pollution 1500-1900’, *Atmospheric Environment* 11: 1157-1162.

Brimblecombe, P. (1978) ‘Interest in air pollution among early Fellows of the Royal Society’, *Notes and Records of the Royal Society of London* 32: 123-9.

Caldararo, N.L. (1987) ‘An Outline History of Conservation in Archaeology and Anthropology as Presented Through its Publications’, *Journal of the American Institute for Conservation* 26, 2: 85-104.

Campbell, L. (1998) ‘The Conservation of Netherlandish Paintings in the Fifteenth and Sixteenth Centuries’, in C. Sitwell and S. Staniforth (ed.) *Studies in the History of Painting Restoration*, London: Archetype Publications.

Caple, C. (2000) *Conservation Skills: Judgement, Method and Decision Making*, London: Routledge.

Caple, C. (2006) *Objects: Reluctant Witnesses to the Past*, Abingdon: Routledge.

Caygill, M. (1992) ‘The Protection of National Treasures at the British Museum During the First World and Second World Wars’, in P. Vandiver, J. Druzik, G. Wheeler and I. Freestone (eds.) *Materials Issues in Art and Archaeology III*, Pittsburgh: Metals Research Society.

Getty Conservation Institute (1992) ‘Preventive Conservation’, *GCI Newsletter* 7 (1) 4-7.

Gilberg, M. (1987) ‘Friedrich Rathgen: The Father of Modern Archaeological Conservation’, *Journal of the American Institute for Conservation* 26, 2: 105-120.

Grzywacz, C.M. (2006) *Monitoring for Gaseous Pollutants in Museum Environments*, Los Angeles: Getty Conservation Institute.

Hatchfield, P.B. (2002) *Pollutants in the Museum Environment*, London : Archetype.

Hicks, H. (1988) ‘Early Approaches to the Conservation of Works of Art on Paper’, in V. Daniels (ed.) *Early Advances in Conservation*, British Museum Occasional Papers No. 65, London: BMP.

Hinton, D.A. (2005) *Gold and Gilt, Pots and Pin,* Oxford: OUP.

Haug, A. (2001) ‘Constituting the Past – Forming the Present: the role of material culture in the Augustinian period’, *Journal of the History of Collections* 13, 2: 111-123.

Jones, A. (2007) *Memory and Material Culture*, Cambridge: CUP.

Lee, L. and Thickett, D. (1996) *Selection of Materials for the Storage or Display of Museum Objects*, British Museum Occasional Paper 111, London : BMP.

Marsh, G. (1981) ‘London’s Samian Supply and its Relationship to the Development of the Gallic Samian Industry’, in A. Anderson and A. Anderson (eds.) *Roman Pottery Research in Britain and North West Europe* (BAR Int. Ser. 123i), Oxford: British Archaeological Reports.

Mann, P. (1994) ‘The Restoration of Vehicles for Use in Research, Exhibition, and Demonstration’, in A. Oddy (ed.) *Restoration: Is It Acceptable?* British Museum Occasional Paper No. 99, London: British Museum Press.

Nissan, K. (1999) ‘The Sword and its Scabbard’, in O. Owen and M. Dalland (eds.) *Scar: A Viking Boat Burial on Sanday, Orkney*, East Linton: Tuckwell Press.

Plenderleith, H. J. (1998) ‘A History of Conservation’, *Studies in Conservation* 43, 3: 129-143.

Pye, E. (2001) *Caring for the Past*, London: James & James.

Rackham, H. (trans) (1968) *Pliny’s Natural History*, London: Heinnemann.

Rowlands, M. (1993) ‘The Role of Memory in the Transmission of Culture’, *World Archaeology* 25, 2: 141-151.

Roy, A. and Smith, P. (eds.) (1994) *Preventive Conservation: Practice, Theory and Research*, IIC Ottawa Congress 12-16 September 1994, Ottawa: IIC.

Saunders , D. (1992) ‘The National Gallery at War’, in P. Vandiver, J. Druzik, G. Wheeler and I. Freestone (eds.) *Materials Issues in Art and Archaeology III*, Pittsburgh: Metals Research Society.

Strong, D.E. (1973) ‘Roman Museums’, in D.E. Strong (ed.) *Archaeological Theory and Practice*, London: Seminar Press.

Thomas, A. (1998) ‘Restoration or renovation: Remuneration and Expectation in Renaissance ‘acconciatura’’, in C. Sitwell and S. Staniforth (ed.) *Studies in the History of Painting Restoration*, London: Archetype Publications.

Thomson, G. (ed.) (1968) *1967 London Conference on Museum Climatology*, London: IIC.

Thomson, G. (1978) *The Museum Environment*, London: Butterworth.

Tweddle, D. 1992: *The Anglian Helmet from 16-22 Coppergate*, The Archaeology of York 17/8. London: CBA.

Ward, R. (1993) ‘A Survey of the Samian Ware from Excavations at Piercebridge’, *Journal of Roman Pottery Studies* 6: 15-22.

Waller, R. (2003) *Cultural Property Risk Analysis Model, Development and Application to Preventive Conservation at the Canadian Museum of Nature*, Goteborg: Acta Universitatis Gothoburgensis.

Waller, R. and Michalski, S. (2004) ‘Effective Preservation: From Reaction to Prediction’, *Getty Conservation Institute Newsletter* 19.1 (Spring 2004): 1-4.

White, R. (1988) *Roman and Celtic Objects from Anglo-Saxon Graves: a catalogue and an interpretation of their use*, BAR(British Series) 161, Oxford: British Archaeological Reports

White, R. (1990) ‘Scrap or Substitute: Roman Material in Anglo-Saxon Graves’, E. Southworth (ed.) *Anglo-Saxon Cemeteries A Reappraisal*, Stroud: Alan Sutton Publishing.

Willmott, H. (2001) ‘A Group of 17th Century Glass Goblets with Restored Stems: Considering the Archaeology of Repair’, *Post Medieval Archaeology* 35: 96-105.

Table 0.1 Developments in Preventive Conservation in Museums

	19th + early 20th century	1930's-1990's	1990's to the present
Light	Natural light provided through windows to view the collection. Some materials which are known to fade such as textiles, prints and drawings are kept in drawers or behind curtains out of direct light.	Guidelines on light levels established. Technology provides accurate means of measuring light levels. Museum lighting is now largely electric controlled to meet the approved levels as part of drive for professional standards.	Requirements of the visitor are considered increasingly important. Desire for increased visibility of collections leads to use of annual light dose concept. Management of the collection to rotate objects. Fluorescent lights for energy efficiency, plus LED and fibre optics for effect.
Insects	Reactive to insect infestations with large scale chemical treatment, Arsenic dust or similar toxic insecticides used.	A range of newer chemicals such as DDT and chlorinated hydrocarbons replace arsenic. Gaseous fumigants such as phosphine, methyl bromide and ethylene oxide regularly used for complete insect eradication.	Integrated Pest Management systems developed; continuous monitoring, removal of all sources of succour dissuades insect activity. Eradication achieved through non-chemical anoxia or thermal treatments.
Incorrect humidity	Awareness of avoiding damp; objects located in appropriate areas of the building to minimise risk of mould. Regular cleaning and maintenance. Limited heating in winter means that low RH conditions are rare.	Awareness of the effect of high and low RH. Central heating from the 1960's leads to low RH problems in the winter. The ability to measure RH raises expectations and by the 1990's strict RH limits for loans. Air conditioning used where tight RH control required.	Revised RH limits mean that strict RH limits rarely necessary. Costs and necessity of air conditioning questioned. Computer based monitoring of the museum environment makes RH, and temperature data increasingly available. Modelling of building microclimates starts.
Disasters (water & fire)	React to individual disasters. Little or no planning until WW2. Establishment of the emergency services reduces loss of life and property. Watchmen widely used.	Fire alarms and smoke detectors increase detection. Professional emergency services and improved fire resistance of materials & building designs by the 1980's reduce fire damage. Disaster / emergency planning established.	Disaster / emergency planning becomes the norm, proactive managed approaches to emergencies developed. Prohibiting smoking in public buildings, increased safety of electrical devices and use of earth leakage circuit breakers reduces the number of fires.
Security	Museum objects have low value and are thus rarely taken, little security needed. Museum attendants and watchmen provide deterrents.	Museum object values rise sharply. Alarms installed in all museums & galleries. Some objects stolen to order, but opportunistic crime is the major increase.	CCTV increasingly used replacing attendants. Security sometimes high but focussed on high value items. Opportunistic crime continues.
Gases & Dust	Dust equated with a lack of care, so objects dusted and cleaned as a social norm. Deleterious effects of gases from burning gas and coal known to some, but lack of alternative heating sources means coal burning continues..	Damaging effects of a wider range of gases on museum objects appreciated. Problems created by some new polymers for museum materials emerge. Materials testing develops. In 1956 Clean Air Act reduces SO_2 and dust levels in Britain. Car pollution emerges as a problem.	Gas and dust monitoring increasingly used. Increasing use of safer materials e.g. polyester sleeves, Plastazoate packaging and absorbers e.g. activated charcoal and molecular sieves. Dust from smoking indoors ceases but NOX pollution levels from cars increase.
Incorrect temperature	Temperatures exclusively for human comfort. No attempt to maintain consistent temperature	Expectations of higher temperatures for human comfort. Increased temperatures increase the	Heating still primarily for human comfort. Level of control = higher. Efforts to reduce heating costs. Some limited use

	levels .	season for and range of pests. Low RH levels result from high levels of heating in winter.	of heating to control RH.
direct physical forces	Objects in glass cases so handling limited. Limited concern over handling., sometimes professionals occasionally cavalier. No protection for objects in earthquakes. Limited object movement since few loans. Levels of care variable..	Objects increasingly handled with gloves, awareness of careful handling and packaging. However, many objects increasingly loaned and travelling long distances. Objects in handling collections and on open display. Precautions against earthquakes, vandalism increasing.	Increasing exhibitions means increasing object movement and handling. Increasing protection from earthquakes and transit through improved materials, case and building design.

Preventive Conservation in Museums

Introduction to Part One - Holistic Approach to Preventive Conservation

Chris Caple

As the Canadian Conservation Institute (CCI) sought to support Canadian museums and the care of their collections, they were concerned that the risks of object damage and loss were not being properly evaluated. Too often museums, following the emphasis in the literature and on museum courses, focussed their limited resources on measuring temperature and humidity rather than installing smoke detectors or basic security measures. Fire and theft were in reality far greater threats to the museum collection than changes in temperature or relative humidity. This led **Charlie Costain**, Stephan Michalski and the CCI staff to create the framework for the preservation of museum collections; a 9 row x 7 column table in which threats (direct physical forces; thieves vandals and displacers; fire; water; pests; contaminants; radiations; incorrect temperature; incorrect humidity) were cross referenced against the museum situation (in storage; on display; in transit). Each cell addressed the threat in each situation with actions to be taken to avoid, block, detect, respond or recover from the threat.

This table was developed circa 1992/3 and in bringing all the threats together focussed the museum profession on a much more holistic approach to preventive conservation. This has had a significant impact, even to the point of suggesting the format for this and other books on preventive conservation. It promoted a far more pragmatic approach by museums and conservators to these problems. It is, however, not the whole story. The table does not assess the level of threat, it does not rate the extent or nature of deterioration, and it does not look at the loss of value of the object. It is, however, an excellent starting point.

In seeking to compare the extent of damage from gradual threats (light, relative humidity, gaseous pollutants, dust), episodic threats (insect attack) and occasional catastrophic threats (fire, flood), conservators such as **Jonathan Ashley-Smith** and Rob Waller (2003) found that the ideas, language and mathematical models of risk analysis provided an appropriate mechanism. A series of important concepts emerged from their work:

- value of an object – recognising that damage reduces value of various types (Ashley-Smith 1999 Chapter 4)
- annual loss rate – which enables very different forms of object decay (gradual, periodic, occasional) in numerous different types of material to be compared, through using this single unit of damage/loss of value
- the use of decision trees and cost benefit analysis as a means of preventive conservation decision making, especially for resource allocation.

There has also been recognition of the need for the materials decay information obtained by scientists to be incorporated with the object loss data generated by conservators to provide increasingly accurate appreciation of the risk of object damage for managers to use in assigning the resources for object care and assessing risks associated with actions such as loaning objects.

REFERENCES

Ashley-Smith, J. (1999) *Risk Assessment for Object Conservation*, Oxford: Butterworth Heinemann.
Waller, R. (2003) *Cultural Property Risk Analysis Model, Development and Application to Preventive Conservation at the Canadian Museum of Nature*, Goteborg: Acta Universitatis Gothoburgensis.

Introduction to Part Two, Section 1 - Agents of Deterioration: Physical Forces (handling and moving) & Security

Chris Caple

The most obvious threat to any object is the physical risk of damage form handling (dropping) or moving the object or impacts on the object. Care and protection against the threat of physical damage, whether it be the kick of a mule or an earthquake, is an essential component of preventive conservation.

Careful object handling is the single most important skill which a curator or conservator can develop to minimise damage to objects. Whilst objects need to be moved for a museum to fulfil its display, storage and education functions effectively, objects broken during moving form part of every museum conservator's workload. **Miles** provides simple, sound, sensible advice about handling museum objects including, being practical about issues such as wearing gloves. There are no simple do and don'ts; each situation must be assessed and appropriate precautions taken. As the loads to be lifted become heavier there is an increase in the level of organisation, equipment required and relevant legislation. In the UK the *Manual Handling Operation Regulations* (*1992*) have to be taken into account. In recent years the provision of modern packaging materials such as: polypropylene plastic crates, bubble wrap and Plastazoate™ (polyethylene foam) which can protect, cushion and support objects has greatly reduced the risks of damage during simple moving and handling operations.

More detailed information on packaging and moving artefacts, especially for historic objects, is available (Read and Hickey *2006)*. **Paul Macon** has summarised much of the practical information on moving objects over longer distances, between rather than within museums, on a web site run by the Canadian Conservation Institute (CCI). Websites represent the medium through which basic museum information will normally be provided in the future, they have the advantages that they can be regularly updated as commercial products or advice changes and that they are potentially available almost anywhere in the world. This site takes its readers, step by step, through the decision making processes which need to be addressed when packing and transporting objects, from selecting a carrier to the cushioning value of various materials and the different designs of packing case. It also makes the reader aware of the range of information already created by CCI on this subject. Though many museums package and courier their own objects, there is also a great deal of knowledge about the safe transportation of objects embedded within the commercial shipping industry. Case studies on moving objects appear regularly in conferences (Ashley-Smith 2008) and journals such as those in *Museum Practice* Vol. 28 (Winter 2004), pages 43-59.

Within the museum literature discussions about storage often focus on its aim of providing objects to support the museum's display and education functions. However, from the preventive conservation point of view, there is a clear objective in preserving collections in the 'as found' state to the point where they are required for use in research, display or education. **Chris Caple** explores that objective and two clear aspirations emerge:

- the aspiration of – a 'black box' ideal of perfect object preservation and access; exploring some of the realistic steps which museums often made towards that objective.

- a simple grading system of the levels of storage clarifying how individual actions grouped together in a series of logical steps can move a chaotic group of objects to a well stored museum collection.

‘ Good storage has a relatively high, even density of objects, in order to make maximum use of beneficial environmental conditions in the store and achieve the lowest cost per object for near ideal storage’ (Caple 2000, 152-4).
High quality storage has been practiced in museums for many years. Published in 1992 **Jim Tate** and **Theo Skinner**, describe the storage systems, created in the National Museum of Scotland. Well designed storage greatly reduces the risks from physical damage and, provided that appropriate materials are used, substantially reduces the risk from the environment around the objects. The range of variables which should be considered when improving storage and the practical activities involved in achieving it were reviewed by Proudlove (2000i, 2000ii). In many areas such as textiles, photographs and transport collections, specialist articles or chapters in books on storage have been published and provide useful detailed advice on materials and methods of safe storage, such as those in the journal *Museum Practice,* Issue 10 (1999), pages 60-83.
The development of inert materials such as:

- polypropylene boxes which form excellent stackable rigid containers
- polyethylene foams such as Plastazoate™ which can act as a cushioning material, be used to form a cut out for movement free seating for objects and provides thermal insulation
- steel cupboards, drawers and shelving units with stoved enamel or powder coated finishes
- polyester sleeves for documents and photographs
- archival quality papers and boxes

is leading to improved object storage. However, there is also continued use of ‘cheap’ materials such MDF, chipboard and lower quality cardboard boxes, all of which emit gases and lose strength over time. Short term thinking remains prevalent in many heritage organisations, aided by the perennial problems of limited resources and a lack of awareness of the problematic nature of these materials by senior managers.
Though conservators and curators normally focus on the collections in public museums, many culturally valued artefacts remain in private possession. In the book *Ours for Keeps?*, the Museums and Galleries Commission (MGC) assembled a range of papers intended to be read by the public and private collectors as well as museum volunteers and staff which provided basic information about care of collections. Information was provided on suitable storage and display conditions, techniques and materials for a large range of different object types. **Pete Winsor**’s section on materials is one of the most useful, clearly explaining what the different materials are and why they are useful for preserving objects. Again the focus is on modern inert materials which have a good track record for safely storing artefacts. Similar information is available through web sites such as www.collectionslink.org.uk/collections care . The availability of preventive care information through a wide range of publicly available information sources; books, web sites and courses helps to preserve these objects for future generations.

Vibration, can occur on a small scale through road traffic and building work, see Chapter 38, or on a large scale in the form of earthquakes. The **IIC** hosted a seminar on the threat of seismic activity (earthquakes) to cultural heritage in Tokyo in July 2009. It was hosted by Jerry Podany, President of IIC, and contains the thoughts of a number of speakers on this subject. Whilst information on precautions which can be taken against the risk of physical damage during seismic activity is available from a number of sources, (Podany 2008), www.eqprotection-museums.org , the majority of the discussion focuses on the improvements to, and availability of, maps of seismic activity and the associated risks to museum artefacts. Whilst some richer countries such as Japan and America have fitted isolators to protect some high value objects in museums in zones of seismic activity, other museums have not yet installed even basic low cost protection measures such as mesh in front of their open museum shelves to prevent objects falling onto the floor during an earthquake.

Though museums have concerns over the safety of objects, either from theft or vandalism, they also have concerns over the safety of visitors, staff and buildings. Consequently safety issues are dealt with in greater detail in collections management publications (Fahy 1995) and specialist publications on museum security (Hoare 1990, Resource 2003). However, consideration does need to be given when storing or displaying objects to measures to minimise the risk of theft or damage of individual objects or groups of objects. As with other areas of preventive conservation, this means assessing the risk to the object. **Rob Payton** describes a simple method for assessing risk to the objects on display in the Museum of London. It shows how particular objects of value (financial or historic) which are at the greatest risk of theft or vandalism damage can be identified and then steps can be taken to safeguard them.

REFERENCES

Ashley-Smith, J. (ed.) (2008) *Conservation and Access, Preprints of the 2008 IIC Congress, London 15-19 September 2008*, London: IIC

Caple, C. (2000) *Conservation Skills: Judgement, Method and Decision Making*, London: Routledge, 152-154.

Fahy, A. (1995) *Collections Management*, Abingdon: Routledge.

Hoare, N. (1990) *Security for Museums*, London: Committee of Area Museum Councils & Museums Association.

Manual Handling. Manual Handling Operations Regulations 1992 (as amended). Guidance on Regulations L23 (Third edition) HSE Books 2004 ISBN 0 7176 2823 X. Also available at http://www.hse.gov.uk/contact/faqs/manualhandling.htm

Podany, J. (ed.) (2008) *Advances in the Protection of Museum Collections from Earthquake Damage*, Los Angeles: J. Paul Getty Museum.

Proudlove C. (2000i) The Perfect Package, *Museum Practice* 14, 40-43.

Proudlove, C. (2000ii) Perfect Package in Practice, *Museum Practice* 15, 40-43.

Read, M and Hickey, S. (2006) 'Transporting Objects', in The National Trust *Manual of Housekeeping*, London: the National Trust.

Resource (2003) *Security in Museums, Archives and Libraries: a Practical Guide*, London: Resource.

Introduction to Part Two, Section 2 - Agents of Deterioration: Fire & Water (disasters)

Chris Caple

The impact of disasters on museum collections goes back to the earliest temple collections in early Rome whilst the provision of documentation to prepare staff and mitigate against the damage from disasters can be seen in the pre-war publication '*Air Raid Precautions in Museums and Picture Galleries and Libraries*', a 60 page booklet written in 1939 by Sir John Fosdyke Director of the British Museum (Caygill 1992). To appreciate the extent of the threat which disasters pose to the artefacts in a museum or an historic house, it is instructive to be reminded of the level of destruction of such events, hence the inclusion of a chapter by **Rowell and Robinson** on the fire and salvage efforts at Uppark, in this reader. The detailed analysis of many such events has made it clear that the provision of appropriate equipment and the planning and training of staff can reduce the impact of such events on collections. In the 1980-90s there were a series of fires in the stately homes of Britain: Hampton Court in 1986, Uppark in 1989, Windsor Castle in 1992. It was the fire at Uppark and the visual impact of its damage and salvage, which gave renewed impetus in Britain to the creation of disaster plans for all museums and historic houses, the creation of disaster teams and the establishment of caches of emergency equipment to aid in dealing with such emergencies. Such preparations had been made prior to 1989 by many organisations including the National Trust, but the events at Uppark added renewed urgency to such preparations. The occurrence of a number of these events in the late 1980s brought home to the UK heritage industry that whilst these events are rare in the life of any one property, when considering all the historic properties and museums in any one country, several major incidents occur every year. This ultimately led to the incorporation of fire and flood (disaster and emergency planning) into the *Framework for Preservation* and an appreciation that reducing the likelihood and impact of fires and flooding was as much part of preventive conservation as reducing the levels of light.

The initial Disaster Plans of the 1980's and 1990's could often be long and detailed affairs. The advice given for disaster preparedness planning, such as that by **John Hunter**, reflected this detailed multi step approach to the subject. Like other publications on this subject (Dorge & Jones 1999) its detail is useful for reminding people of the many things which should be considered. However, the disaster planning document created was often very large and only limited sections, particularly the appendices, were needed in practice. In an effort to encourage museums, historic houses and even private collections to engage in disaster preparedness several organisations provided information on disaster and emergency planning on web sites:

http://www.english-heritage.org.uk/upload/pdf/Flooding_and_Historic_Buildings._Technical_Advice_Note_2004.pdf

http://www.getty.edu/conservation/publications/pdf_publications/emergency_plan.pdf

http://icom.museum/disaster_preparedness.html

http://www.collectionslink.org.uk/plan_for_emergencies

The focus on disaster preparedness planning which followed the fires at Hampton Court, Uppark, and Winsor Castle, in the 1980s and 1990s emphasised the recovery of collections, the use of disaster recovery teams and access to disaster recovery equipment and materials. 'Disaster Plans' became widespread in the UK in the 1990's and were a formal requirement for all accredited museums and archives in England by 2004. However, in recent years their emphasis changed, the term 'emergency planning' has become more widely used with a remit for dealing with any emergency situations which would arise in the museum. Three separate teams; emergency planning, emergency response and salvage team, are mentioned by **David Martin**. Though several members of these teams are the same additional specialists are present in each one. The broadening of the remit reflects a desire for more effective use of the resources and training consumed by disaster planning. However, as Martin's article shows, the heart of the emergency plan is still the same well structured 'Disaster Plan' created in the 1990's. The slightly jaded statement that 'opinions vary about the value of kits of equipment and materials that might be needed in a disaster' merely reflects a decade of museum directors tripping over sheets of plywood and polythene sheets in the corner of a small museum, ready for a disaster which has yet to arrive.

Some of the more recent events such as the damage or looting of museums caught up in conflicts in countries such as Kuwait, former Yugoslavia, Chechnya and Iraq has emphasised the need for the emergency planning procedures of museums of many countries to engage with relevant for war or conflict situations. Most of these procedures are those outlined much earlier by Noblecourt (1956) (Stanley-Price 1997). However, the events of September 11th, 2001 brought home to many museums outside 'traditional' conflict zones their unpreparedness for terrorism and the impact it could have on their collections (Heritage Preservation 2002).

REFERENCES

Caygill, M. (1992) 'The Protection of National Treasures at the British Museum During the First World and Second World Wars', in P. Vandiver, J. Druzik, G. Wheeler and I. Freestone (eds.) *Materials Issues in Art and Archaeology III*, Pittsburgh, Metals Research Society, 29-99.
Dorge, V. and Jones, S.L. (1999) *Building an Emergency Plan: A Guide for Museums and Other Cultural Institutions*, Los Angeles: The Getty Conservation Institute.
Heritage Preservation (2002) *Cataclysm and Challenge: Impact of September 1, 2001 on Our Nation's Cultural Heritage*, New York: Heritage Preservation.
Noblecourt, A. (1956) Protection of Cultural property in the Event of Armed Conflict, *Museums and Monuments VIII*, Paris: UNESCO.
Stanley-Price, N. (1997) War and the Conservator: 1 Preventive Measures and Recovery, *Museum Management and Curatorship* 16, 2, 155-159.

Introduction to Part Two, Section 3 - Agents of Deterioration: Pests

Chris Caple

Prior to the 1980's insect infestations of museum objects or collections were normally dealt with in a reactive manner. Upon discovery of an infestation, the object or collection was fumigated, sprayed or dusted with chemical agents that were toxic to insects, and could potentially be deleterious to human health. Prior to the 1970's these had included arsenic and DDT. However by the 1990's a proactive approach was being adopted, with prevention recognised as more cost effective than cure. This approach, known as 'integrated pest management' is here described by **Dave Pinniger and Pete Winsor**. It has now also been adapted to use the same avoid, block, detect, respond (recover) as the Framework for Preservation (Strang & Kigawa 2009). To be successful it relies on an effective museum management who can, for example, ensure that a member of staff remains responsible for maintaining insect trapping information, that quarantine and housekeeping procedures are maintained and that museum wide assessments for, and elimination of, food sources, access points and harbourage for insects are regularly carried out.

It is no coincidence that that integrated pest management systems were being adopted, and alternative approaches to eradicating insects such as freezing, heating and anoxia, became increasingly used in the museum community just as legislation to restrict the use of chemical insecticides was being enacted. The use of integrated pest management techniques does require a higher level of organisational control than the mass fumigation approach of earlier years, and in most museums increasing levels of managerial control were evident in the 1980's. It should also be noted that the demise of wild animals through the loss of their habitat was the subject of increasing awareness and concern from the 1960's onwards. It is ultimately this technique which was adopted and developed as 'housekeeping' which forms the basis of the integrated pest management systems which began to be applied in museums from the mid 1980's (Story 1985,). Since the 1980's we have been moving away from the chemical treatments of the 19th and early 20th century to the management and control approach that characterises the late 20th and early 21st century.

Whilst freezing has been used for treating insect infestations since the 1970s (Zycherman & Schrock 1988; Florian 1997; Strang 1992) and integrated pest management systems, since he mid 1980s, case studies reporting such 'routine' activities have only rarely been submitted or published in journals of conferences in recent years (Berry 2001). The paper by **Hillyer and Blyth** first appeared in *The Conservator* in 1992, reprinted later in Simon Knell's, *Care of Collections*, (1994). It is a good example of the implementation of an integrated pest management strategy and of the use of freezing as a method of insect eradication.

Much of the literature selected for this reader refers to the problems faced by objects in the museums and historic houses of the UK and North America; this reflects the large volume of literature produced in Britain and North America on preventive conservation as well as the experiences of your editor. Elsewhere in the world similar problems exist but the details vary. **Lim Chong Quek, Muhammadin Razak and Mary Ballard** describe the differences between museum insect pests in North America and South East Asia. There work provides a timely reminder that all the advice and information provided in this reader should be evaluated by the reader with reference to their local conditions, the resources available and with regard to the objects with which they are working.

REFERENCES

Berry, J. (2001) 'Battle of the Beasts: Treatment of a Pest Infestation of the Mounted Mammal Collection at Liverpool Museum', in H. Kingsley, D. Pinniger, A. Xavier-Rowe & P. Winsor (eds.) *2001 Pest Odyssey: Integrated Pest Management for Collections*, 130-134.

Florian, M-L. (1997) *Heritage Eaters, Insect and Fungi in Heritage Collections*, London: James & James.

Strang, T.J.K. (1992) 'A Review of Published Temperatures for the Control of Insect Pests in Museums', *Collections Forum* 8, 2, 41-67.

Strang, T. and Kigawa, R. (2009) *Combating Pests of Cultural Property*, CCI Technical Bulletin 29, Ottawa: CCI.

Story, K.O. (1985) *Approaches to Pest Management*, Washington DC: Conservation Analytical Laboratory, Smithsonian Institution.

Zycherman, L.A. and Schrock, J.R. (1988) *A Guide to Museum Pest Control*, Washington DC.: Foundation of the American Institute for Conservation of Historic and Artistic works and the Association of Systematics Collection.

Introduction to Part Two, Section 4 - Agents of Deterioration: Contaminants (gasses and dust)

Chris Caple

The environment which surrounds an object is composed of the storage or display materials, the gaseous environment and the fine particles (dust) suspended in that gas. **Sarah Stanniforth, Sophie Julien & Linda Bullock** provide a simple, non-technical introduction to gaseous pollutants , a topic which can quickly become highly technical and very scientific. Their article clearly describes the gases which react with artefacts, their origin, their damaging effects and the methods used in monitoring and minimising the concentrations of these gases. More detailed information especially on storage and display materials and the gases they can emit is available from Tétreault (2003) and Hatchfield (2002).

Following the initial development of the Oddy test in the British Museum the 1970's, **Lee and Thickett** in British Museum Occasional Paper 111 produced a 'standard' work on the principal gaseous pollutants in museums, their reactions with the artefacts in the collections and the application of the Oddy Test. It provides full details of the Oddy test; the industry standard test for storage and display materials used to ascertain the extent to which they emit gases which could be harmful to museum artefacts and specimens. It also provides, like a number of other publications (Tétreault 1994), information on materials which are considered safe for storage and display as well as methods to minimise the risk from pollutant gases from less safe materials . British Museum Occasional Paper 111 also provides details of a number of further 'instant' tests such as the iodine-iodate, azide and Beilstein test about the chemical composition of materials and thus an indicator of their possible reaction with museum objects, though these tests are far less accurate regarding the degree of threat to artefacts than Oddy tests. Details of materials and their suppliers, which the British Museum has tested and found to be safe for use in storing and displaying museum artefacts and specimens are also found in this publication.

Research work on gaseous pollutants has been carried out at the British Museum for over 30 years. The results of this testing was published by **Bradley and Thickett**. It provides a particularly detailed look at the reduced sulphur gases and VOC's (volatile organic compounds,) such as formaldehyde and ethanoic (acetic) acid pollutants, present in the galleries of the British Museum. This study shows that the situation is more complex than decay triggered by the presence of a polluting gas. The concentration of the gas, the relative humidity, the nature of the artefact and the history of the artefact (whether it has undergone conservation or not) are all shown to affect the likelihood of decay.

Whilst monitoring gasses , eliminating damaging gasses is the defensive approach to the subject, the knowledge of the reaction of artefacts and gasses allows the creation of a proactive approach, deliberately creating microclimates, storing objects in a gaseous environment which will have a benign or beneficial effect. Boxes, frames and other containers have been used to give protection to paintings against physical, insect and light damage since the medieval period. Now objects are sealed in gas tight enclosures to prevent contact with harmful gases. These microclimates have been used for some time, such as storing archaeological ironwork at low relative humidity (RH) or storing silver in enclosures which exclude sulphurous gases. However, in recent decades there has been particular interest in creating anoxic (oxygen free) environments. In 1994 Gilberg and Grattan (1994) outlined the use of 'Ageless'™ and oxygen impermeable polymers for creating oxygen free storage for museum artefacts. This system has been used on a range of historic artefacts in particular decaying plastics for which there are few other storage options. In recent years the Ageless™ system has been superseded by the Revolutionary Preservation (RP) System™. **Mathias, Ransdale and Nixon** explore the use of the RP System™ for storing archaeological ironwork. A number of conservators in the USA and Europe are currently experimenting using the RP-A System™ for storing corroded ironwork (Guggenheimer & Thickett 2008) since they believe that its ability to create both low RH and anoxic conditions are the best ones for preserving corroded ironwork.

The problems of dust, a perennial problem for historic houses such as the numerous properties owned by the National Trust are clearly described by **Helen Lloyd and Katie Lithgow**. Their work shows the heightened level of consciousness now evident at the Trust regarding the nature of dust and its deposition. Simple 'remove it' attitudes have been superseded by awareness of the damage which removal can do, and the greater need to understand how and where it is deposited and what steps can be taken to reduce that deposition. The move to a proactive rather than reactive approach is clearly evident. The benefits of knowing the distribution and level of dust deposition are demonstrated through a series of case studies at National Trust properties and a Royal Palace described by **Helen Lloyd, Katie Lithgow, Peter Brimblecombe, Young Hun Yoon, Kate Frame and Barry Knight**. These demonstrate that although there are different vertical and horizontal dust distribution patterns at each site, some factors appear relatively constant. Visitors are a clear source of dust, the closer to the objects they are, the more the artefacts are soiled. Soiling can be reduced by raising objects 30 cm above the floor (in most cases), moving them further away from the entrance to the property and further away from the visitor route. Drugget and entrance mats reduce dust. External surfaces can also have a significant effect on the amount and nature of dust. The beneficial role of individual property analysis is clear and the mechanism for undertaking basic dust distribution surveys is shown to be relatively simple.

REFERENCES

Gilberg, M. and Grattan, D. (1994) 'Oxygen Free Storage Using 'Ageless' Oxygen Absorber', in A. Roy and P. Smith (eds.) *Preventive Conservation Practice Theory and Research, IIC 1994 Conference, Ottawa*. London: IIC, 171-173.

Guggenheimer, S. and Thickett, D. (2008) 'Investigation into the Potential of Low Oxygen Storage for Freshly Excavated Iron Artefacts: Fundamental Research using the Revolutionary Preservation System (RP-System)', *VDR Beitrage* 1, 75-86.

Hatchfield, P.B. (2002) *Pollutants in the Museum Environment*, London: Archetype

Tétreault, J. (1994) Display Materials: the Good The Bad and the Ugly. www.cci-icc.gc.ca/publications/cidb/view-document_e.aspx?Document_ID=83

Tétreault, J. (2003) *Airborne Pollutants in Museums, Galleries and Archives: Risk Assessment, Control Strategies and Preservation Management*, Ottawa, CCI

Introduction to Part Two, Section 5 - Agents of Deterioration: Radiation (light)

Chris Caple

The paradox that light is essential in order to see artefacts but that damages many artefacts made of organic materials, has been understood since antiquity. **Linda Bullock** provides a lucid and comprehensible explanation of the problems which light can pose for the artefacts in an historic house. Her article avoids the complex chemistry of the interactions between light and materials, which is covered in more detailed textbooks (Schaeffer 2001). Problems such as the monitoring of light and UV levels and the steps which can be taken to control them, are dealt with very clearly. Whi8lst annual light dose is often the preffered approach to controlling the exposure of artefacts to light in historic buildings, in museums there is a greater emphasis on using, where appropriate, the 50 and 200 lux maxima since they have the ability to group together objects, such as textiles, with similar light sensitivity in the same gallery. In museums there is also less emphasis on daylight and greater emphasis on the use of electric illuminance sources. The spectral distribution and questions of colour rendering become important in such museums and galleries. Illuminance sources are covered in detail in dedicated textbooks (IESNA 1996).

The initial recommendations (light level maxima of 50 and 150 lux) from Thomsen (1978) were initially proposed since the amount of light falling on the object, since this was more easily measured than the rate of damage such as fading. However, as recent work by **Boris Pretzel** shows developments in technology now enable light damage as fading to be accurately measured. Developments in levels of human visual perception mean that there is a working model of how much a colour can change (i.e. fade) before it is noticeable (JND – just noticeable difference); 1.5 units of CIEDE2000 (an international measure of colour). This means that for the first time through testing the rate at which the different colours of a specific object will fade an estimate of the light dose an object can receive before a detectable fading has occurred can be made. Key ethical issues still remain as individual museum authorities still need to specify the rate of noticeable fading they consider acceptable. Unfortunately as many factors affect the rate of fading and accurate measurements are only obtainable from experimental light fading directly on a small representative area of the object itself this system will probably only be used on a small number of high profile objects in the foreseeable future. However, when such information is available and integrated with records of display (handling & movement) history, preventive conservation will have potentially moved a step closer to being an object specific, objective, proactive process.

REFERENCES

Schaeffer, T.T. (2001) *Effects of Light on Materials in Collections*, Research in Conservation, Los Angeles: Getty Publications.

IESNA (1996) *Museum and Art Gallery Lighting: A Recommended Practice*, New York, Illuminating Engineering Society of North America.

Introduction to Part Two, Section 6 - Agents of Deterioration: Temperature and Relative Humidity

Chris Caple

Aware of the deleterious effect on many museum objects of either damp or very dry conditions, conservators and curators often set specific relative humidity limits for artefacts going on loan to other institutions. Over time these RH limits became increasingly restrictive and by the late 1980's these limits were not realistically achievable (Ashley-Smith et. al, 1994). In the mid 1990's research these papers **Michalski** and **Erhardt and Mecklenburg** and others suggested that the 'safe' limits for objects and materials were much broader than had previously been suggested. Michalski's paper in particular provides the data to show that: the likelihood of mould growth at RH below 75% is very low; the mid range fluctuation for unconfined organic materials does not lead to any significant mechanical damage over many thousands of cycles; that objects formed from materials which respond at different rates to RH or are confined through rigid joints or fixings are more at risk of failure (cracking or splitting) than unconfined objects and the size and shape of the object can be crucial in determining their likelihood of damage to RH changes or extremes. All this evidence demonstrated that many organic artefacts are less likely to be damaged by mid range RH values between 25 % and 75% high, than had previously appreciated. The research demonstrated that there is a valid basis for assertions that; the risks associated with relative humidity (RH) should ideally be evaluated on an individual object basis, the very limited range of acceptable RH values previously quoted for many objects were often not required and it can therefore be suggested that the money spent on achieving such controlled levels would be better spent on reducing other, greater threats to object safety.

Although there has been considerable focus on relative humidity **Michalski (1994)** also reminds us that in addition to being the crucial driver of relative humidity, temperature also has a wide range of effects on museum objects and materials, though again extreme temperatures represent the greatest threat to objects.

REFERENCES

Ashley-Smith, L. Umney, N. and Ford, D. (1994) 'Let's be Honest – Realistic Environmental Parameters for Loaned Objects', in A. Roy and P. Smith (eds.) *Preventive Conservation: Practice, Theory and Research, IIC Ottawa Congress 12-16 September 1994*, Ottawa: IIC, 28-31.

Introduction to Part Three, Section 1 – Environmental Management

Chris Caple

The ability to monitor and record information about the museum environment improved through the 20th century, and in particular after the development of usable small computers in the 1980's, much greater emphasis was placed on using this information to manage the collections and mitigate the museum environment.

The humidity and temperature in museums and historic houses can be controlled to different levels, depending on the nature of the building its contents and the desired level of RH and temperature control. Though there was considerable development of air conditioning (HVAC – heating, ventilation and air conditioning) systems in the period after the Second World War, it proved expensive to use air conditioning systems to maintain the precise levels of RH, which were becoming considered unnecessary for safe storage and display of museum objects by the 1990's. Since the oil crisis of 1973 and the dramatic increase in the price of energy there has been an increasing emphasis on natural ventilation, zonation, buffering, insulation and use of the thermal mass of the building to make best use of the building's natural ability to control its own environment. **May Cassar** explores the mechanisms used to obtain the desired museum environment, from individual humidifiers and de-humidifiers to full air-conditioning and Building Management Systems. The high cost of energy, the cost of the plant and revised ideas about the need for such tight RH controls have encouraged many museums, galleries and historic houses to explore more natural and cost effective ways of controlling their environments since the 1990's. Some of the pitfalls of large expensive air conditioning systems (capital and running costs) and the problems of ensuring they perform to agreed specification are highlighted by Cassar.

The assessment of collections and their physical condition occurred only very occasionally prior to the 1990s, usually triggered by the arrival of a new curator or conservator, who was keen to know the state of the collections for which they had become responsible. Spurred on by the publication of one or two examples of surveys by individual institutions (Walker & Bacon 1987) a UK National Committee suggested a more standardised methodology and terminology (Keene 1991). As described by **Keene** subsequent assessments have normally achieved much greater rigour through using standardised terms and had a firmer statistical basis for the process. The condition survey was useful since it could be adapted to answer a range of questions. Thus, when combined with environmental monitoring information it could show the impact of environmental conditions on the collections, when combined with curatorial (value) priority it could provide a powerful tool for resource allocation, and when combined with information on storage materials and labour costs it enabled accurate estimates of the resources required for restoring sections of the collection to be created. Though it is widely appreciated that there is potentially some subjectivity in the process (Taylor & Stevenson 1999), through staff training and the use of a calibration process (collection of objects which all assessors survey and then standardise their results to ensure they see and score the condition of the same objects in the same way) the variation between assessors is minimised. The ready availability of spreadsheets and databases on laptop computers mean that nowadays data is often directly entered onto a computer, consequently it is now easier and quicker to conduct such surveys than when Keene wrote about this in 1991. However

problems remain, such as the limited skills of conservators and curators in materials identification.
A clear demonstration of how to adapt a condition survey to meet the demands of a large and very varied collection of objects in non-standard storage systems, spread over multiple sites is provided by S**arah Kingsley and Rob Payton**. Breaking the complete assemblage into a series of smaller sub-collections, dividing these up by a floor grid and adapting the sampling strategy to the nature of the sub-collections enables the data to be rigorously collected and through appropriate mathematical correction of the differently sampled parts of the collection the data combined to give an accurate picture of the state and nature of the whole collection.
There is further advice on how to undertake such work on web sites such as:
http://www.collectionslink.org.uk/conserve_objects/independent_conservators/condition_surveys
and the results of some surveys can be found at: http://cool.conservation-us.org/bytopic/survres/.
Though collection condition surveys provided information on the extent and nature of the decay of artefacts, the amount of conservation and storage work required was invariably so large that some form of prioritisation was required. **Diane Dollery** provided one of the first published examples from the UK of combined condition and curatorial assessments. In addition to a collection condition assessment, the National Museum of Wales set about giving the objects values for the information they could provide about the past or their ability to form a displayable object. A similar classification of 'cultural and historic value' of objects was also devised in the early 1990's by the Dutch for their Delta Plan (Cannon Brooks 1993). Ultimately this approach enabled objects with high display potential and significant historical meaning but in poor condition to be prioritised over the badly damaged but less informative or the attractive but relatively historically meaningless objects. This enabled teams of curators and conservators to establish a prioritised order for conservation and storage work which maximised the preservation of the archaeological value of the collections of the museum.

REFERENCES

Cannon Brooks, P. (1993) The 'Delta Plan' for the Preservation of Cultural Heritage in the Netherlands, *Museum Management and Curatorship* 12, 303-317.
Keene, S. (1991) 'Audits of care: framework for collections condition survey', in M. Norman and V. Todd *Storage,* preprints for the UKIC Conference 'Restoration '91'
Taylor, J. and Stevenson, S. (1999) 'Investigating Subjectivity within Collection Condition Surveys', *Museum Management and Curatorship* 18, 1, 19-42.
Walker, K. and Bacon, L. (1987) 'A condition survey of specimens in the Horniman Museum: a progress report', in J. Black (ed.) *Recent advances in the Conservation and Analysis of Artifacts*, London: Summer Schools Press

Introduction to Part Three, Section 2 – Ethical Considerations

Chris Caple

Though it may be imagined that preventive conservation is completely benign to objects, avoiding the damaging effects of light by storing it in the dark or preventing insects from damaging objects by killing them through freezing, this is not always the case. As **Miriam Clavir** shows simply preventing damage to the physical form of the object fails to take into account of the non-physical (intangible) aspects of the object. In cultures where the object is believed to have personal or human traits, freezing the object, even storing it with other inappropriate objects, or allowing it to be handled by inappropriate people may be considered to have harmed the spiritual or cultural aspects of the object's identity and thus its conceptual integrity.

Clavir's paper reminds those undertaking preventive conservation of the wider context of museum developments in the 1990's; especially the increasing awareness of the social context of collections. The need for museums to engage with the public and to be aware of the conceptual integrity (intangible social and cultural attributes) of objects is emphasised. The implications of a holistic approach to artefacts which includes dealing with intangible social and cultural attributes of native American artefacts is explored. The steps which the Museum of New Mexico has taken to develop storage facilities which preserve the conceptual integrity of the object, even enabling ceremonies such as ritual feeding of objects to take place safely are described.

The increasing awareness of intangible aspects of cultural heritage continued and is reflected in the UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage (2003), the implications of which are discussed in *Museum International* Vol. 56, No. 1-2 (May 2004). This awareness has also been reflected by conservators in the development of the ethical codes, such as The Burra Charter (rev 1999) (Jokilehto 2009). However, the practical difficulties of knowing what the cultural significance is of many of the objects in our museum collections remains a considerable problem (Clavir 2009).

Different museums have been more or less active in tackling this issue. The National Museum of the American Indian (NMAI) has a mandate to 'consult, collaborate and cooperate with Native American peoples'. This applies as much to preventive conservation work, as to any other aspect of the museum's activities. In the same way that modern health and safety legislation modifies what activities and materials can be used, so the NMAI conservators modify what preventive conservation work is done to objects to ensure that it accords with the beliefs of the tribes to whom the objects are ascribed. As **Drumheller and Kaminitz** describe, this means identifying objects over which there are rules or taboos, identifying accurately what those rules and taboos are, then establishing what should or should not be done to the objects and finally working out how this can be reconciled with modern museum practice.

Clavir's 'conceptual integrity' does not only apply to ethnographic objects, but includes all artefacts, especially those which have an artistic, religious or working role. **Child** explores how objects in the Big Pit Museum, and even the mine itself, not only exist as physical examples of a particular type of tool or engine, together they form part of the complete picture/experience of a 20th century coal mine and are all an integral part of a working mine. Removed from their present positions (context) or having their appearance altered (to preserve them), they would lose their role in that picture and degrade the picture/experience. Thus they need to stay in their present position and in their present (less than ideal) conditions or lose part of their conceptual integrity. They are also functioning parts of a working coal mine governed by mining regulations designed to ensure safe working underground. For this machinery will need to be maintained, modified or replaced in order to meet regulations. Seeking to preserve such objects in their present state, must be measured against these other requirements. The loss of visitor experience and reduction in visitor safety must be measured against the damage to the object. Wherever possible compromises are sought, but if coalmining is to be fully appreciated and understood, that means going underground in a realistic context and it means seeing all the objects together in working condition, as they would have been in the past, degraded but, where required, amended to maintain their functional condition. In similar museums such as Beamish in Northern England, the museum seeks a minimum of two examples of each object, one to use as a working object and one to be stored for research and evidential purposes.

As with ethnographic objects (McGhee 1994) the materials of which a work of art is made can be important for their cultural or social meaning. However, those materials, as in the case of ice sculptures, may be impermanent. This impermanence may be part of their meaning; though this will depend both on the meaning of the artwork and the views of the artist or creator of the artwork. The same materials may also be present in the museum collections, without symbolic meaning, simply as a record of the place and period. The preventive conservation approach to such impermanent materials may thus vary from artwork to artwork and collection to collection. One example of such a material is chocolate. **Glenn Wharton, Sharon Blank & Claire Dean** provide details of the chemistry and decay of chocolate and provides examples of a number of museum artefacts made of chocolate. Their paper details how conservators have enacted interventive and preventive conservation measures on these chocolate objects. Threats from insects, pests, vandalism and the environment are countered with a series of avoiding, blocking and eradication actions, determined largely by the artists' wishes.

REFERENCES

Clavir, M. (2009) 'Conservation and Cultural Significance', in A. Richmond and A. Bracker (eds.) *Conservation: Principles, Dilemmas and Uncomfortable Truths*, London: Butterworth-Heinnemann, 139-149.

Jokilehto, J. (2009) 'Conservation Principles in the International Context', in A. Richmond and A. Bracker (eds.) *Conservation: Principles, Dilemmas and Uncomfortable Truths*, London: Butterworth Heinnemann, 73-83.

McGhee, R. (1994) 'Ivory for the Sea Woman: the symbolic attributes of prehistoric technology', in S.M. Pearce (ed.) *Interpreting Objects and Collections*, London: Routledge

Introduction to Part Three, Section 3 – All Together Now

Chris Caple

The problems of preventive conservation never occur in isolation. Large complex collections located in historic buildings comprising objects made of numerous different materials (with differing ideal storage conditions) each have complex social and contextual meanings, are normal. Consequently all proposed preventive conservation measures must be considered together.

The scientific knowledge underpinning preventive conservation increased during the 20th century as did the availability of specialist skills, materials and equipment. This meant that the disparity between the highest and lowest standards of museum collection care increased. Museum Councils had been established in the UK from 1963, to raise standards in museums. In the 1990's the Museum Councils oversight body, the Museums and Galleries Commission (MGC) commissioned a series of publication '*Standards of Care* …. , which described the appropriate conditions for preserving particular types of museum collections; Archaeological, Biological, Geological, Larger & Working Objects, Photographic, Musical Instrument, Costume & Textile and Touring Exhibitions. These are available via http://www.collectionslink.org.uk/conserve_objects/standards_colls_care

They helped to raise the collections care standards in UK museums and as part of that process in 1998 the **Museum and Galleries Commission** produced the *Levels of Collections Care: Self-Assessment Checklist*. It enabled museums to assess their own standards of collections care and appreciate what was required to raise their standards to those described in the 'Standards' series. This publication also emphasised the need for a holistic approach to collections care and helped museums recognise that, for example, whilst their humidity and temperature monitoring system met the 'Best Practice' requirement, their maintenance procedures for their buildings barely made the 'Basic' standard. This enabled museums to better focus their resources to achieve the greatest preventive conservation benefit for their collection. It has given greater emphasis to some of the unglamorous procedures and away from some of the expensive technology. These 'Levels of Collections Care' can be seen as having the same aims as the CCI 'Framework for Preservation'. The incremental approach of moving from 'Basic' to 'Best Practice' in the 'Levels of Collections Care' corresponded well with the aspirations of many museums and their staff.

National and international heritage agencies recognise that collections care needs to be fully integrated into the core activities of every museum. This is often best achieved through a teamwork approach involving a wide range of museum staff, not merely conservators or curators. Organisations such as ICCROM seek to emphasise this through relevant publications (Putt & Slade 2004). A similar strategy is also seen in the UK where cultural collections management publications (Resource 2002; British Standards Institute 2009) have drawn from the earlier *Levels of Collections Care* work and used its checklist format to encourage self-awareness in integrating collections care into their museums core curatorial activities.

The term holistic approach to preventive conservation is easy to use, the challenge is to manage the processes of obtaining information to make informed decisions and get agreed priorities. **Keene** shows through a number of examples how a holistic approach to preventive conservation can be effected in practice. Key points include:

- The organisation must want to achieve high standards of care for its collections and have developed appropriate policies and the mechanisms to implement them if it is to achieve the standards of care which ensure the long term preservation of its collections.
- There is a need to turn data into useful improvements in collections care. To do this data on humidity, temperature, light, pollution and pest levels must be developed into information which can be readily understood by colleagues and can be used to formulate decisions ultimately actions that reduce the risks faced by objects in the museum environment.
- Engage with the reality of buildings, their operation and maintenance. There is a need to appraise critically the fabric of buildings and analyse critically the process of monitoring and maintaining the buildings' environment to ensure that what is supposed to happen actually occurs. It is essential that staff understand accurately and completely every step in the process if the museum environment is to effectively controlled.

Resources are a key issue in the extent and nature of preventive conservation work which can be done. Good organisation and planning can minimise the problem of limited resources. **Catherine Nightingale's** paper explores the problems, particularly that of dust, faced by conservators, designers and curators in seeking to create an exhibition of fashion clothing in the Linbury Gallery of the Museum of London with insufficient funds to build museum cases for all the clothing. This meant dealing with the problems of costume on open display. Nightingale's paper shows that by understanding, in detail, dust distribution patterns and the risks to the objects from visitor touch, through using simple precautions such as plinths, high and low barriers and locating objects at distances greater than 1.5m from the visitors, the risks to the objects could be minimised. Crucially through monitoring the dust levels conservators were able to assure the museum that dust level mitigation strategies were effective. The light levels, in the 50-100 lux range, were higher than the normally recommended 50 lux maxima for textiles, though as the exhibition only ran for 9 months, the annual light doses for the objects were in practice well below recommended annual levels. Interestingly, although the gallery was air conditioned, the RH levels were only between 45% and 65% for 70% of the time. The extremes of RH are not recorded, though the temperature fluctuations between 28^{o}C and 11^{o}C in this gallery may go some way to explain the RH fluctuation. There may be concern that for 30% of the time the objects were outside the 46-65% band, but most unconfined textiles can cope with such RH fluctuation and the more 'at risk' objects were in glass cases and so protected from the RH extremes. This paper demonstrates how modern conservators and curators are engaging actively with the concept of risk, which is increasingly being judged at an individual object level.

The realities of museum life mean that there are regular instances of collections remaining in museums buildings in which building work is being undertaken. The case study by **Siobhan Watts, Janet Berry, Amy de Joia, Fiona Philpott** of building work undertaken in Liverpool Museum and the Walker Gallery, explores the threats from vibration and dust to the collection whilst it remained stored or displayed in the building under renovation. It demonstrates the need for pragmatic risk assessment; identifying and removing objects at greatest risk from vibration damage before work starts; putting into place vibration and dust monitoring procedures and establishing 'working' standards of 0.5G for vibration and 5 soiling units per week (soiling unit = 1% reduction in light reflection) based on previously published work. Despite initial testing to ensure that building activities did not exceed working standards, active monitoring during the process showed failures to control both dust and vibration by the contractor. It revealed the need both for regular meetings between museum staff and building contractors and even occasional direct intervention to halt potentially damaging situations. The importance of communication and the need for management and control of building work as part of a preventive conservation approach is very clearly demonstrated.

The challenges of preventive conservation are, perhaps, at their greatest for objects on open display in often unheated buildings such as those at St Fagan's; the National Folk Museum of Wales. **Sue Renault** describes how all the 'agents of deterioration' are present and active with the additional handicap of curatorial neglect, seen in the form of previous inexpert cleaning, which has damaged a number of the objects. The benefits of authentic, powerful and sensory stimulating displays in open air museums (Shafernich 1993) must be balanced with the damage to artefacts which open coal fires and human contact brings. The risks to the object from continued open display are assessed with reference to the extent of visitor access. Smaller objects are considered sufficiently safe from theft behind 'roped off' areas, but they are removed from display areas with unrestricted visitor access, as the risk of theft is assessed as too high (see Paper 9). This creates false visual differences between displays in different buildings or different areas of the same building, thus affecting visitors perceptions of life in Post medieval rural Wales.

Renault also describes how at St Fagan's one of the key elements in the assessment of risk of open displays is the number of visitors a property receives; the higher the visitor numbers, the greater the damage (intentional and unintentional) which is done. The damage they cause varies from property to property depending on its contents and the materials from which they are made. This leads to restrictions to access and closing properties. This is a good example of the 'carrying capacities' of historic properties; the numbers of people who can visit the property with minimal risk to the historic fabric and contents. This question of carrying capacities has been discussed in detail by Helen Lloyd (2006).

REFERENCES

British Standards Institute (2009) *PAS197:2009 Code of Practice for Cultural Collections Management*, London: BSI

Lloyd, H. (2006) 'Opening Historic Houses', in *The National Trust, Manual of Housekeeping*, London: Butterworth-Heinemann, 671-685.

Putt, N. and Slade, S. (2004) *Teamwork for Preventive Conservation*, Rome: ICCROM http://www.iccrom.org/pdf/ICCROM_01_Teamwork_en.pdf

Resource (2002) *Benchmarks in Collections Care for Museums, Archives and Libraries*, London: Resource.

Shafernich, S.M. (1993) 'On Site Museums, Open Air Museums, Museum Villages and Living History Museums: Reconstructions and Period Rooms in the United States and the United Kingdom', *Museum Management and Curatorship* 12, 43-61.

Introduction to Part Three, Section 4 – The Future

Chris Caple

The future cannot be known until it has become the present. It is, however, already possible to glimpse some of the issues such as preservation in situ, DNA, expert systems and climate, which will represent significant challenges to preventive conservation in the foreseeable future.

The ability to travel, our desire for more intense experiences, our appreciation of the importance of context in making buildings and objects more meaningful and our recognition of the rights of individual nations, regions and groups has meant that historic sites and their contents are increasingly likely to be preserved 'in situ' rather than being brought to the 'treasure house' museums of major European and North American cities. As our technical abilities and the resources available for heritage work increase so our ability to preserve artefacts in challenging environments and remote locations is improving. The most extreme examples of this phenomenon would appear to be the huts and their contents from the 'heroic period' of Antarctic exploration (1899-1917) located on Ross Island in Antarctica. **Julian Bickersteth, Sarah Clayton & Fiona Tennant** describe the extremity of the challenge of mitigating the effect of the climatic conditions and practising preventive conservation in such an inhospitable environment. Though it would be possible to transfer these huts and their contents in their entirety to Australia, New Zealand or Europe, the context of seeing them in the desolate wilderness of the Antarctica conveys the importance and meaning of these huts far more eloquently than any label ever could. They are an important monument to the history and development of the Antarctic, an early 20th century wooden shed has infinitely less meaning in the museum of a large urban conurbation than when it is only one of a handful of buildings present on a continent. The practical difficulties of enacting preventive conservation on these buildings and objects does not rest simply with the extreme climatic conditions but also with the problems of distance, the numerous different materials, and the surrounding presence of a fragile protected natural environment which cannot be disturbed. There are also major managerial challenges, wrestling with the complexity of organisations and international politics, the lack of a national funding body and the fact that research has often not been done into the decay mechanisms and conservation of materials in these climatic conditions (Barr & Chaplin 2004).

It is tempting to think that through implementing our present preventive conservation measures we are preserving our museum collections but this may only be true at a macro visual level. As **Julian Carter** suggests this may not be the case at the microbiological level. Developments in microbiological research have meant that it is now appreciated that museum collections contain an invaluable information resource in the form of DNA, whose decay cannot be seen, but which it is essential to preserve as unique research resource for the future. Similar arguments can be advanced for the need to preserve the microscopic traces of body fluids on textiles (Eastop and Brooks 1996), organic residues on ceramics (Evershed et. al. 2001), insect traces in the dirt on archaeological artefacts (Fell 1996) and organic material impressions preserved in metal corrosion (Janaway 1984). The chemical composition, microbiological make up or microscopic physical traces of museum objects are as much part of the physical evidence of our past as the shape and decoration of the object. It is increasingly important that we develop preventive conservation techniques for preserving this evidence of our past. This is a new and challenging technical frontier for conservators and curators, which is expanding as our technical ability to recover molecular and microscopic information increases.

As both the levels of knowledge about preventive conservation are growing and the expectations of museum directors, curators and conservators are rising, the decisions for those practising preventive conservation, are becoming more complex. To explore how we may manage this situation in the future, **Rob Waller and Stefan Michalski** outlined a scenario in a modern day museum in which the need for accurate assessment of the risk to objects is demonstrated. They recognise that such assessments were previously achieved through knowledge, experience and common sense. However, as the body of knowledge grows, the time and capacity to acquire and use this information decreases whilst the pressure for access to objects increases. There is also an increasing expectation that decisions will be justified with a plethora of facts and figures. They argue that there is an increasing need for an 'expert system' which could utilise all the available information and express risk in mathematical terms on a common and understandable scale, such as annual (object) loss rate. The authors then explore the state of development of such expert systems. The risk management system is, they suggest, getting nearer and when it is working it will be 'the future' of preventive conservation.

Though we may be slowly coming to grips with many of the preventive conservation problems presented by our present collections in our existing museums buildings, the present situation will not continue as we live in an ever changing world. One of the most fundamental changes we potentially face is that of changes to our climate. The initial work on the impact of climate change on heritage in the UK has been spearheaded by May Cassar (2005). It is clear that more extreme weather events will occur and they will do so with increased frequency. **May Cassar and Robyn Pender** explore some of the challenges this will bring. For example the predicted infrequent but occasionally high levels of rainfall could lead to the needing to adapt historic buildings to cope with more rainwater. Though this could be met by building overflows for gutters, this alters the historic building fabric, which raises significant ethical questions such as, what is the point of preserving an inaccurate and only partially truthful past?

Climatic changes such as the increasing temperature levels in the tundra mean that archaeological remains preserved by the permafrost in places such as Greenland are now being lost as the permafrost levels thaw. The international threat posed by changing climate was the subject of an **IIC** seminar held in London 2008, hosted by Jerry Podany, President of IIC, and Sarah Staniforth of the National Trust and featuring a number of invited speakers, including, Professor Christina Sabbioni, Professor May Cassar, James Reilly and Michael Henry. They highlighted the steps which are being made to apply the information from climate prediction models to historic buildings and objects in either historic houses or museums. The speakers explored the problems at a number of scales and highlighted a variety of problems. The need to operate historic buildings and historic collections in a more sustainable way, consuming less energy was a common theme. The high energy cost of creating rigid environmental conditions was mentioned by many speakers and most argued for the need to review environmental standards and the benefits of taking a more object specific approach to the preventive conservation.

REFERENCES

Barr, S. and Chaplin, P. (2004) *Cultural Heritage in the Arctic and Antarctic Regions*, Oslo: ICOMOS IPHC

Cassar, M. (2005) *Climate Change and the Historic Environment*, London: Centre for Sustainable Heritage.

Eastop. D. and Brooks, M. (1996) ‘To Clean or Not to Clean: The Value of Soils and Creases’, *ICOM-CC 11th Triennial Meeting, Edinburgh 1996*, Edinburgh: ICOM-CC.

Evershed, R.P., S.N. Dudd, Lockheart, M.J. and Jim, S. (2001) ‘Lipids in Archaeology’, in Brothwell, D.R. and A.M. Pollard (eds.) *Handbook of Archaeological Sciences*. London: Wiley.

Fell, V. (1996) ‘Washing Away the Evidence’, in A. Roy and P. Smith (eds.) *Archaeological Conservation and its Consequences, 1996 IIC Copenhagen Congress*, London: IIC.

Janaway, R. (1984) ‘Textile Fibre Characteristics Preserved by Metal Corrosion: the potential of SEM studies’, *The Conservator* 7: 48-52.